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THE ICOR MODEL

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The BDM Corporation
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McLean, Virginia 22102

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EXECUTIVE SUMMARY
THE ICOR MODEL

1.1   BACKGROUND

This report is intended to provide the reader with an overview of the processes and capabilities of the Integrated Corps (ICOR) model. It includes an overview of the model methodology and a brief description of the various modules which model specific processes. Before getting into the methodology, it is helpful to understand the manner in which ICOR developed.

During the past three years, the simulation which is now called "ICOR" or "The Integrated Corps Model" has undergone considerable growth and redirection. Its origin is depicted in Figure I-1. CLEW I was developed from TCOR. It originally was designed to support a corps level electronic warfare evaluation and was modified a second time to support a subsequent EW analysis. With ICOR's most recent growth, it has been used to support TRADOC's Fire Support Mission Area Analysis. In addition, with its conversion to the VAX11/780 at CACDA, it will become the prototype of TRADOC's new Corps/Division Model (CORDIVEM).

This redirection in model emphasis has been reflected in the nature of the growth pattern for ICOR. First, the Operation Reaction System was added. This revamped the combat and reaction processes. Then the artillery module was added as well as the conventional logistics module to support the Division 86 Interdiction Task Force. Next, an explicit air defense module, an improved artillery representation, an improved sensor module, and a nuclear logistics module was added. These development efforts significantly improved the modeling fidelity of the physical processes represented in the model. These processes will be highlighted in this chapter and expanded upon in the next chapter.

The dashed lines in the figure represent model efforts that influenced the design considerations in the development of ICOR. The overall development of the ICOR model has resulted in a greatly improved simulation of land-air conflict capable of meeting most of the requirements
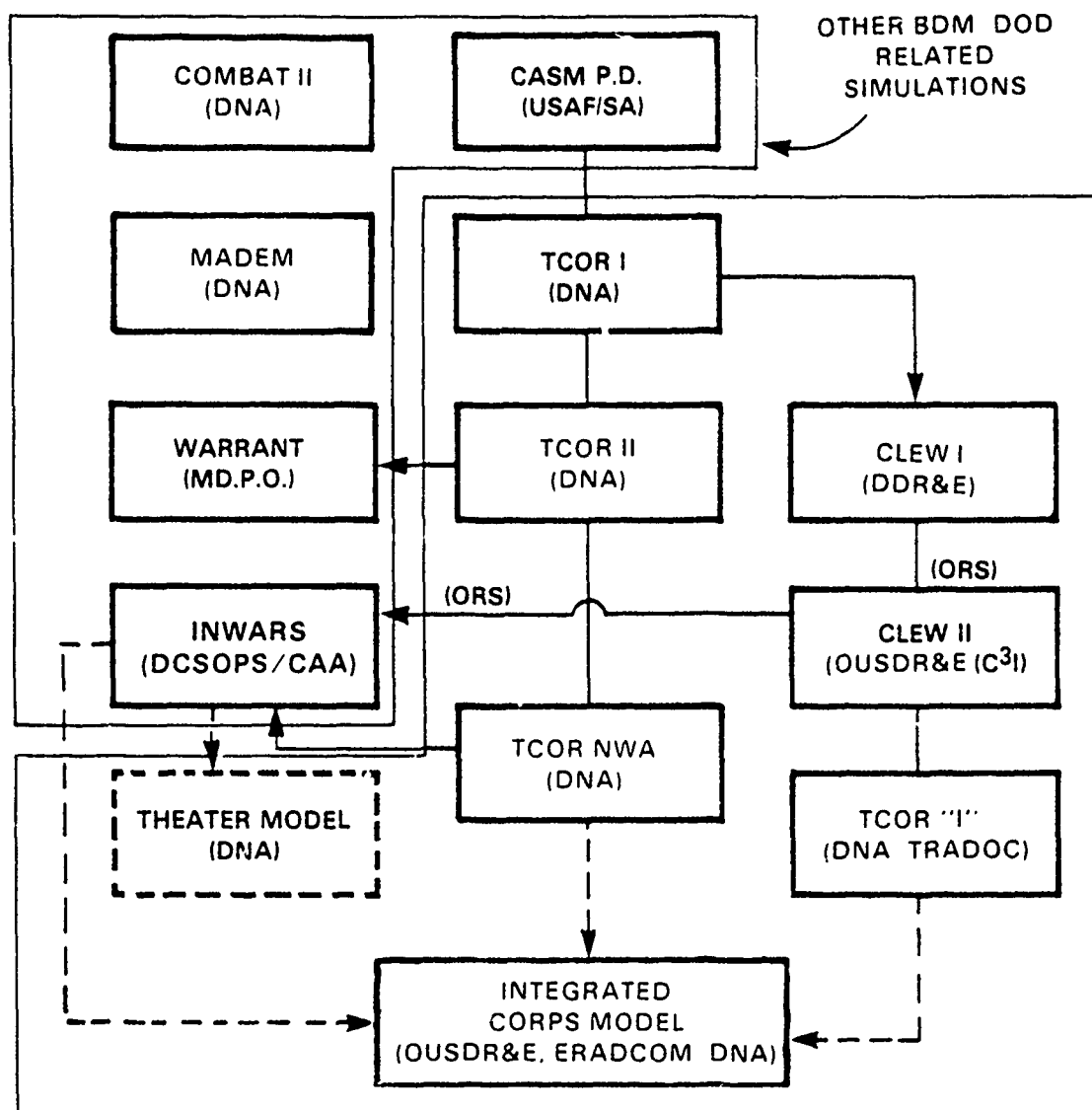
Figure 1-1. The ICOR Simulation System and Its Antecedents

for analysis of issues relating to force structure, weapons effectiveness, and mission area analysis. One of its strengths is that it has been built in a modular fashion and as a result can be expanded and adapted to meet specific requirements of future users.

1.2   GENERAL DESCRIPTION

The ICOR model is a two-sided, event-stepped, unit-centered simulation of ground and air-ground combat. It can include any size geographical area but normally a corps size area is used for the Blue forces and an army area for the Red forces. This might cover an area 100 km x 300 km. In this scenario there would be approximately 500 units in its current configuration. The basic units represented are battalions, and in some cases individual companies, batteries, platoons, or sensors. These units maneuver in accordance with operation orders issued to them by a man-in-the-loop (MITL) commander and by automated decision making processes which govern unit movement and operational status. The man-in-the-loop performs the functions of the command/control hierarchy above the basic unit level. Each unit includes various assets including individual weapons, trucks, supplies, and others as initially assigned. They fire and are attrited using a weapon on target type of attrition mechanism. The terrain representation utilizes a hexagonal grid of 3.5 km resolution in which various type of roads and rivers and varying degrees of roughness, forestation, and urbanization are represented. Units move from hex to hex, interacting directly with units in adjacent hexes, as governed by their operation orders.

The block diagram in Figure 1-2 presents a functional breakdown of the capabilities modeled in the ICOR model. The top-down structured modeling approach utilized in ICOR ensures that the spectrum of activities in a combined arms campaign receives adequate consideration consistent with the resources available. Although the emphasis in the last few applications of ICOR was on fire support/interdiction mission analysis, the evolution of the model was from a sensor/intelligence orientation which included both air support operations and logistics. The breadth of the features considered in the simulation, along with the efficient software

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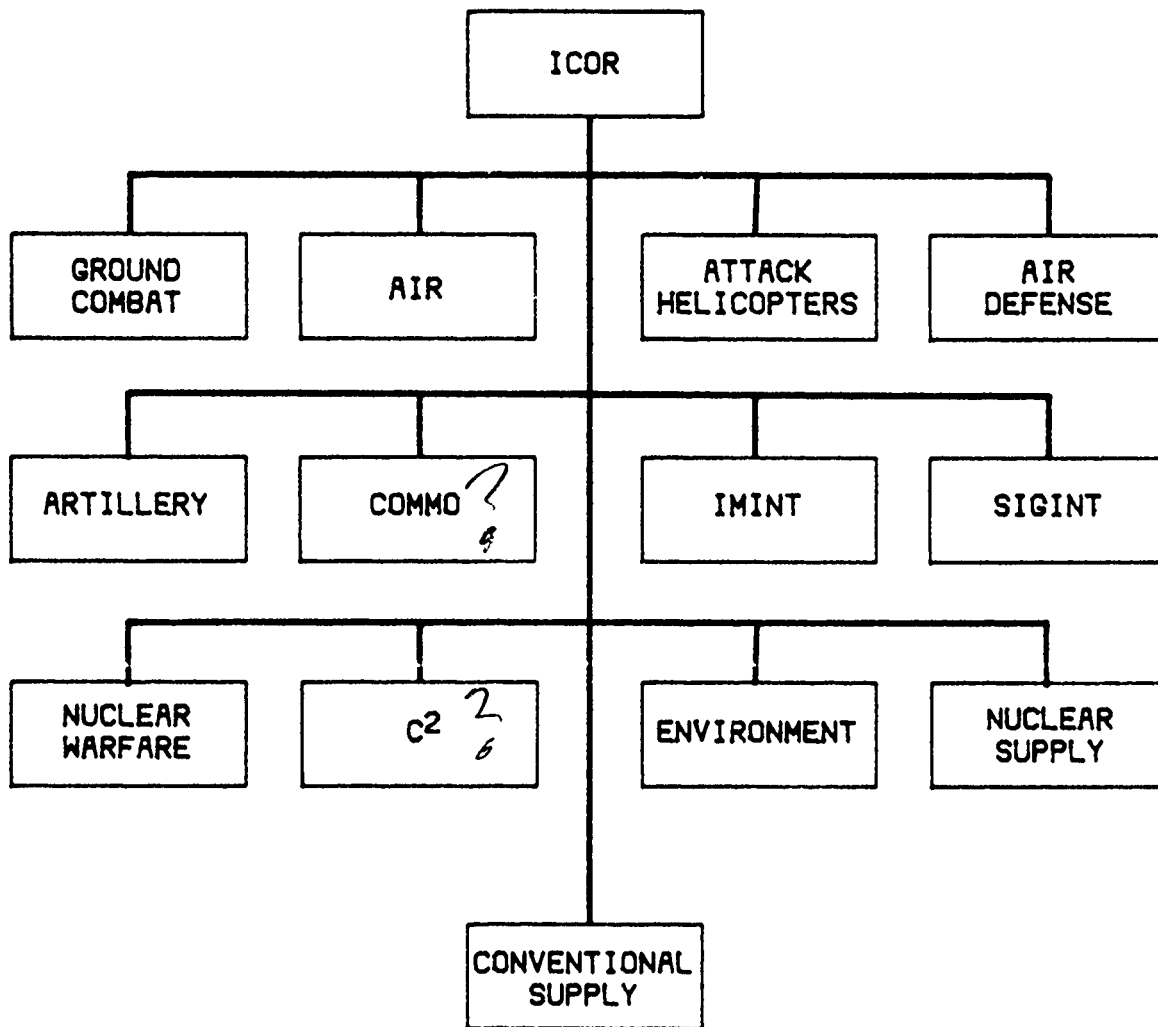
Figure 1-2.   ICOR Functional Areas

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design, has made ICOR a credible, useful study tool for a variety of analyses.

1.3   MODEL STRUCTURE

The ICOR model explicitly represents units with a "scoreboard" within the dynamically allocated memory which contains the current status of a particular unit including its identity, strength, assets, and pointers to related structures such as operation orders and sensor assets. Events which involve a unit, such as combat, movement, sensor operation, etc., are scheduled on a discrete event list. The model runs by sequentially executing software modules associated with the different types of events as they occur chronologically. This structure has allowed a modular approach to the implementation of specific features while utilizing common Simulation Control Software (SCS) for event processing, memory space management, and other utility functions.

1.4   IMPLEMENTATION FORM

The ICOR model is written in FORTRAN with data structures implemented using a language called MIDAS. The latter allows much greater flexibility and program clarity then can be achieved with basic FORTRAN. The ICOR model requires about 220 K octal 60 bit words of memory to run on the CDC Cyber 176. The model has been modified to run on a CDC 6400 series computer as well as a Vax 11/780.

Operation is normally in the batch mode for each interval of two to four simulated hours of combat. The state of the model at the conclusion of each interval run, consisting primarily of the dynamically allocated memory called ISPACE, may be saved for setting the starting state of the subsequent run, for archival purposes, and for reference by interactive programs.

Thus, ICOR is run by submission of many short batch runs with card or interactive inputs and printer and graphics outputs being the manner in which the man-in-the-loop commanders interact with the model.

CHAPTER 2
THE ICOR MODEL DESCRIPTION

2.1   MODEL OVERVIEW AND GENERAL FEATURES

The ICOR model is a two-sided, corps-level computerized wargame of air and ground combat operations. It plays the movement of individual ground combat units in a two dimensional sense in that units are not restricted to artificial corridors, as is the case with sector models, but can maneuver as the situation dictates constrained only by terrain, opposing forces, and orders. It also does not require the user to impose an artificial partition on the battlefield.

All elements of a combined arms operation are included. Maneuver and fire support units are represented as explicit entities with inherent decisionmaking capabilities. Within each of the individual combat units, each major weapon type is explicitly represented. There is no aggregation of weapons. Indirect fire weapons engage by firing battery, platoon, or any user defined volleys against acquired targets. Aircraft, including attack helicopters, acquire and engage targets, utilizing expected kills per sortie for precision munitions, or fractional damage for area munitions. Explicit representation of individual air defense systems, with relatively detailed ground-to-air engagements, provide the source of aircraft attrition. A less detailed air defense treatment is also available and will be discussed later in this chapter.

Other characteristics and capabilities of the model are that it plays explicit intelligence collection by imaging and passive electronic warfare systems, and it has explicit representation of the effects of terrain and weather on unit fire and maneuver. Another key capability of the model is its "man-in-the-loop" (MITL) feature, which allows actual battle staff gamers to interact with the model and make the high-level decisions.

2.1.1 PLAYER CENTERED MODELING

ICOR is "player-centered," with players representing decision-making elements at the various command levels. These automated or partially automated command elements control entities such as maneuver, fire support, and logistic units which in turn are engaged in dynamic physical processes. The simulation focuses on realistic portrayals of the interactions between decisionmaking, force, and logistic elements. (See Figure 2-1.)

PLAYER CENTERED MODELING

DIRECT ORGANIZATION AROUND
DECISION MAKING FORCE
ELEMENTS

PLAYER CENTERING PROVIDES
OPERATIONALLY RECOGNIZABLE
ACTIONS AND EVENTS WHICH
ARE MEANINGFUL TO OPERATIONAL
USERS
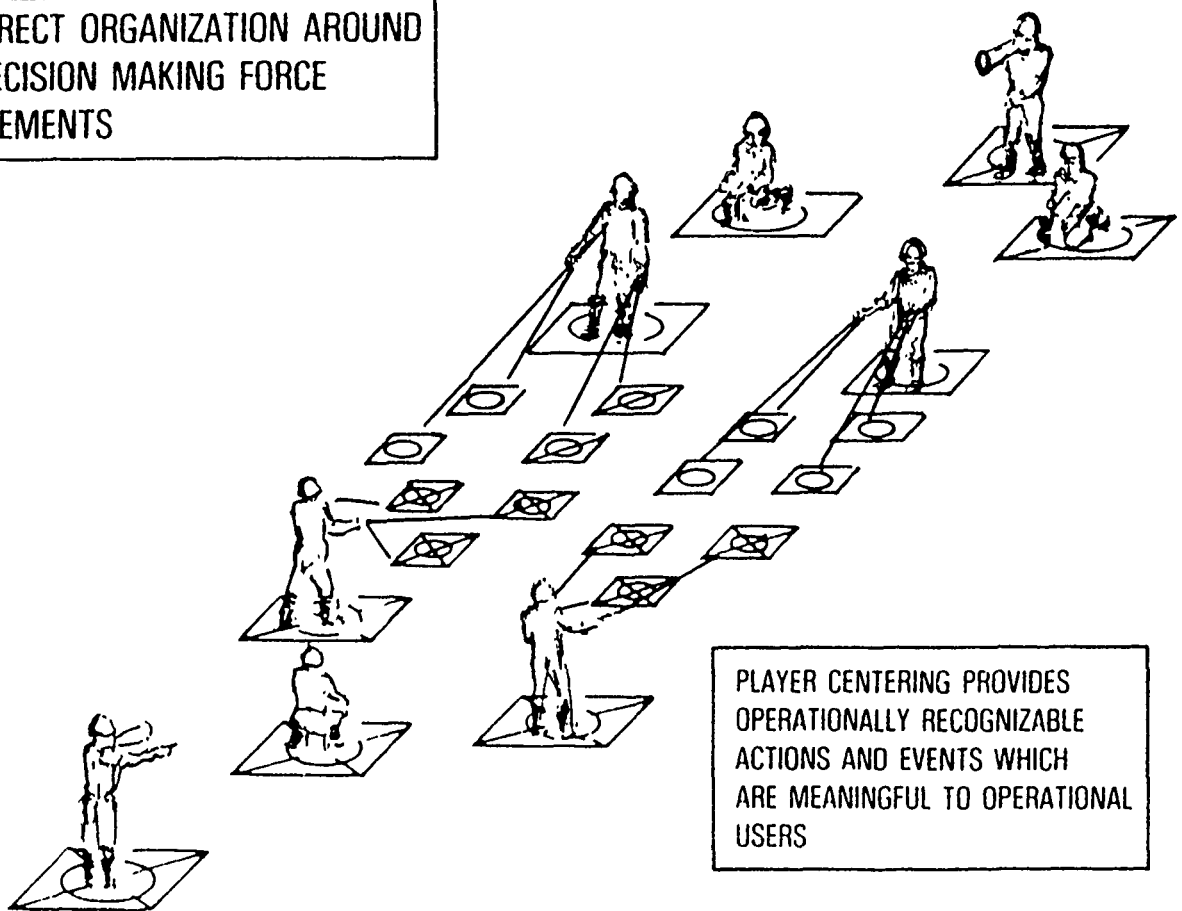
Figure 2-1. Player Centered Modeling

Maneuver units are normally of battalion size, although troops or companies can be accommodated. These units are explicitly located on the battlefield with an inventory of materiel specified by quantity, type, and characteristics. Maneuver units move, shoot, observe, and send messages in response to the local combat situation and orders from their commanders.

Fire support units include artillery, TACAIR, and attack helicopters. Field artillery units are typically of battalion size, but can be represented as batteries or platoons. As with maneuver units, the nature of their materiel assets distinguishes them from other units. Air defense artillery is represented either implicitly or explicitly as required.* Air units are flights of variable sizes and types of aircraft. Flights are also distinguished by the area where they operate (FLOT or rear of the battlefield) and their expected performance in terms of target kills and losses per sortie.

Combat service support units are currently limited to supply and transportation types. Supply units are capable of receiving and disbursing supplies in response to demands from supported units. Transportation units are convoys that move between supply units, loading and unloading supplies as appropriate on arrival.

2.1.2   MAN-IN-THE-LOOP OPERATIONS

ICOR operates on an interrupt-restart basis and can be used with an interactive input/output processing capability. With this capability, the man-in-the-loop may play a variety of roles, depending on the problem being investigated, manpower available, and the preferences of the user. Typically, one or more persons act as the decisionmaker for a particular side, playing numerous roles from corps/army commander to brigade/regiment commander when required. In doing this, players modify the nature of the role being played to correspond to the authority, responsibilities, and information available (as appropriate to the command level) when planning

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*   Explicit representation of air defense weapons and radars is provided for. The user can elect to use this feature or the implicit relationship which assesses a fixed loss per sortie for both Red and Blue aircraft. Additional discussion of the explicit air defense module is included in Appendix E.

and preparing operations orders or fragmentary orders for the maneuver, fire support, logistics, and sensor units. In other cases, one person may play the role of corps commander, giving operations orders to other analysts acting as subordinate commanders. These orders are normally given only to react to unforeseen situations on the battlefield. Units react automatically in carrying out their operations orders. Figure 2-2 illustrates.

ICOR has, as an integral part of the simulation, explicit message generation and transfer mechanism through the communications module. Man-in-the-loop inputs such as operations orders are processed as messages within the model. Similarly, other messages generated by subordinates, including requests for fire support and unit status reports, are processed as communications. This feature is an essential part of the simulation process in that messages stimulate the generation of actions leading to events. The information transfer is the key to the action-reaction dynamics and the analysis of counter-C^3 capabilities.

2.1.3   HEXAGONAL COORDINATE SYSTEM

The ICOR model employs a hexagonal (hex) coordinate system for locating units on the battlefield. One of the hex properties is their ability to be nested or clustered in groups of seven to make a larger hexagon as shown. The basic hex diameter used in ICOR is 3.57 kilometers, which is typical of the space one would expect a battalion-sized unit to occupy. Each hexagon has an address block which records information on environmental factors such as elevation and other terrain data (i.e., terrain-influenced indexes reflecting terrain and cover and governing maneuver and attrition). Figure 2-3 illustrates the hex numbering system.

2.1.4   ENVIRONMENT

Numerous indices have been included in the data structure relating to the characteristics of each hex. This allows the implementation of categorization schemes and determination of resultant effects of such features as terrain roughness and vegetation, topography, presence of built-up areas, presence of roads, rivers, bridges, and both natural and

MAN-IN-THE-LOOP OPERATIONS
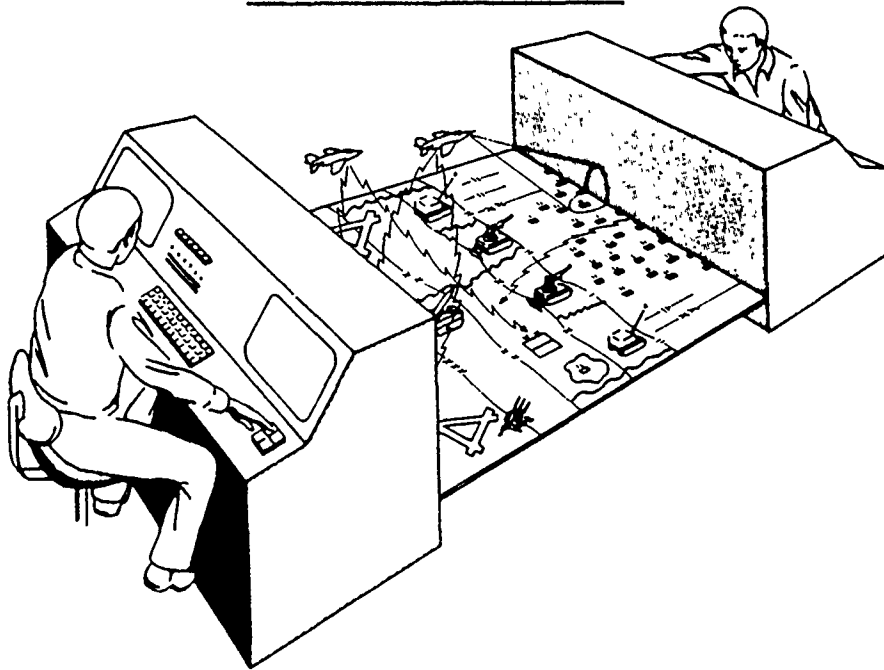
"ANALYST-IN-THE-LOOP" ENABLES:
- GUIDANCE OF SITUATION EVOLUTION
- EXPLORATION OF "WHAT-IF" ISSUES

"COMMANDER-IN-THE-LOOP" ENABLES:
- TEST AND REFINEMENT OF AUTOMATED C^2I PROCESSES
- USE AS A TRAINING VEHICLE

Figure 2-2.   Man-in-the-Loop Operations

HEX POSITION LOCATION SYSTEM

INTERNAL "COORDINATE SYSTEM" BASED ON NESTED HEXAGONAL REGIONS

SCALE:

0   100   KM.   200   300
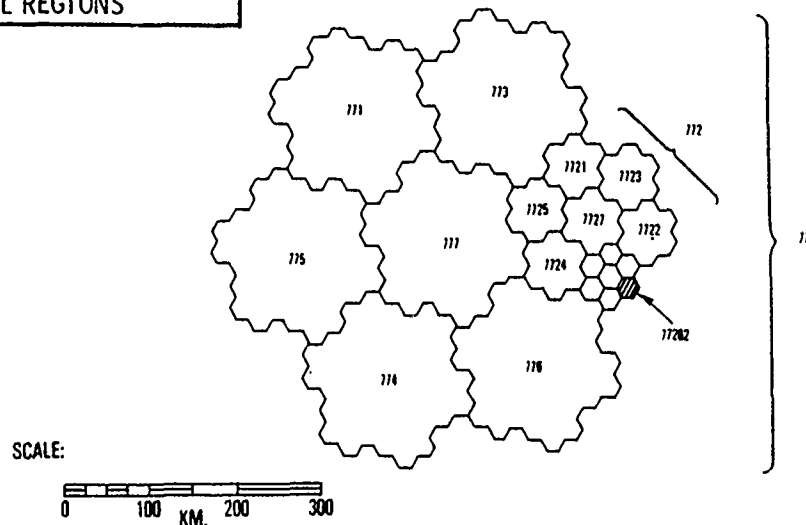
- REALISTIC REPRESENTATION OF MANEUVER
- WIDER POSSIBILITIES FOR UNIT INTERACTIONS
- SIGNIFICANT COMPUTATIONAL EFFICIENCY

Figure. 2-3.   Hex Position Location System

artificial barriers. These features generally have an effect on the ease of movement and the choice of movement direction, the target acquisition probabilities, and the relative attrition. In addition, day and night are simulated by their effects on movement and visibility.

The model uses an aggregated representation of terrain. A hex grid is used to form the cells for aggregation, with the smallest hex size employed in the current analysis being 3.57 km in "diameter." (This is not a software limitation, but was selected as a satisfactory compromise between resolution and cost, e.g., core storage, run time, etc.) Each cell has been characterized in terms of percentage of cell area that is built-up, forested and mountainous. This characterization influences movement; that is, allowable movement rates are constrained by urbanization, foresta-tion, and general terrain roughness. Other terrain features that influence movement, such as rivers and roads, are represented by assigning "traffic-ability levels" to each hex side. This allows the general orientation of barriers or roads to further influence trafficability. For example, a major north-south road through a hex will not assist east-west movements. Figures 2-4 and 2-5 illustrate.

Terrain characterization also influences combat. For example, a unit defending in a relatively open area will receive higher casualties than that same unit in a similar situation, but defending in a heavily forested area.

2.2   GROUND COMBAT OPERATIONS

Ground combat takes place when units of opposing sides occupy positions that are in the same or adjacent hexes. It is represented in the model as the action of a unit firing on all adj..cent enemy units. The intensity of combat is greater when the former situation exists. The outcomes of the combat process are evaluated at a fixed time interval (usually five minutes) using a formula which considers the firing units current strengths by weapon, disposition of the opposing units, the kill rates of the specific weapon types available, the terrain on which the combat is taking place, and suppression effects due to indirect and direct

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ICOR MAP KEY

Terrain Roughness
1 = terrain slope avg>.03 overall or≈15% hills or rugged terrain
2 = terrain slope avg>.06 overall or≈40% hills or very rugged terrain
3 = terrain slope avg>.1 or most of hex impassable to vehicles

River

1 = STREAM
2 = RIVER
3 = MAJOR
    RIVER

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Extent Built-up
1≈15%
2≈40%
3≈70%

Extent Forested
1≈15%
2≈40%
3≈70%
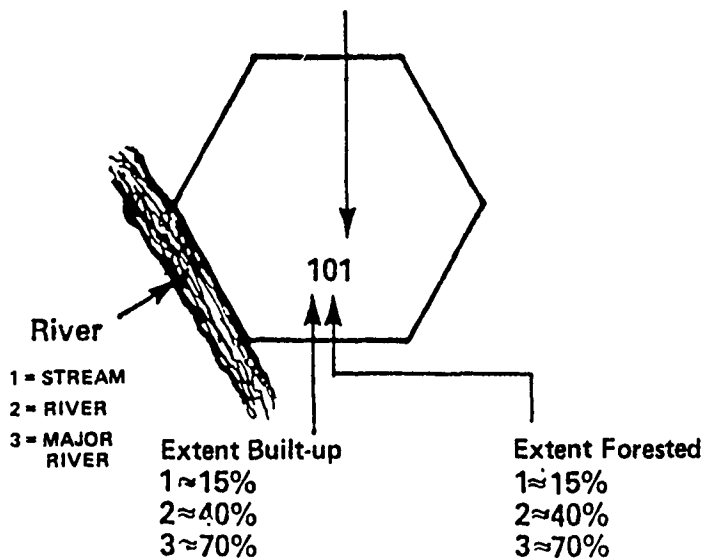
Roads:
Roads do not always correspond one to one with actual highways, but rather indicate the extent to which two hexes are connected.

Autobahn:
Primary:
Secondary:
Tertiary:

5613/78W

Figure 2-4. ICOR Map Key

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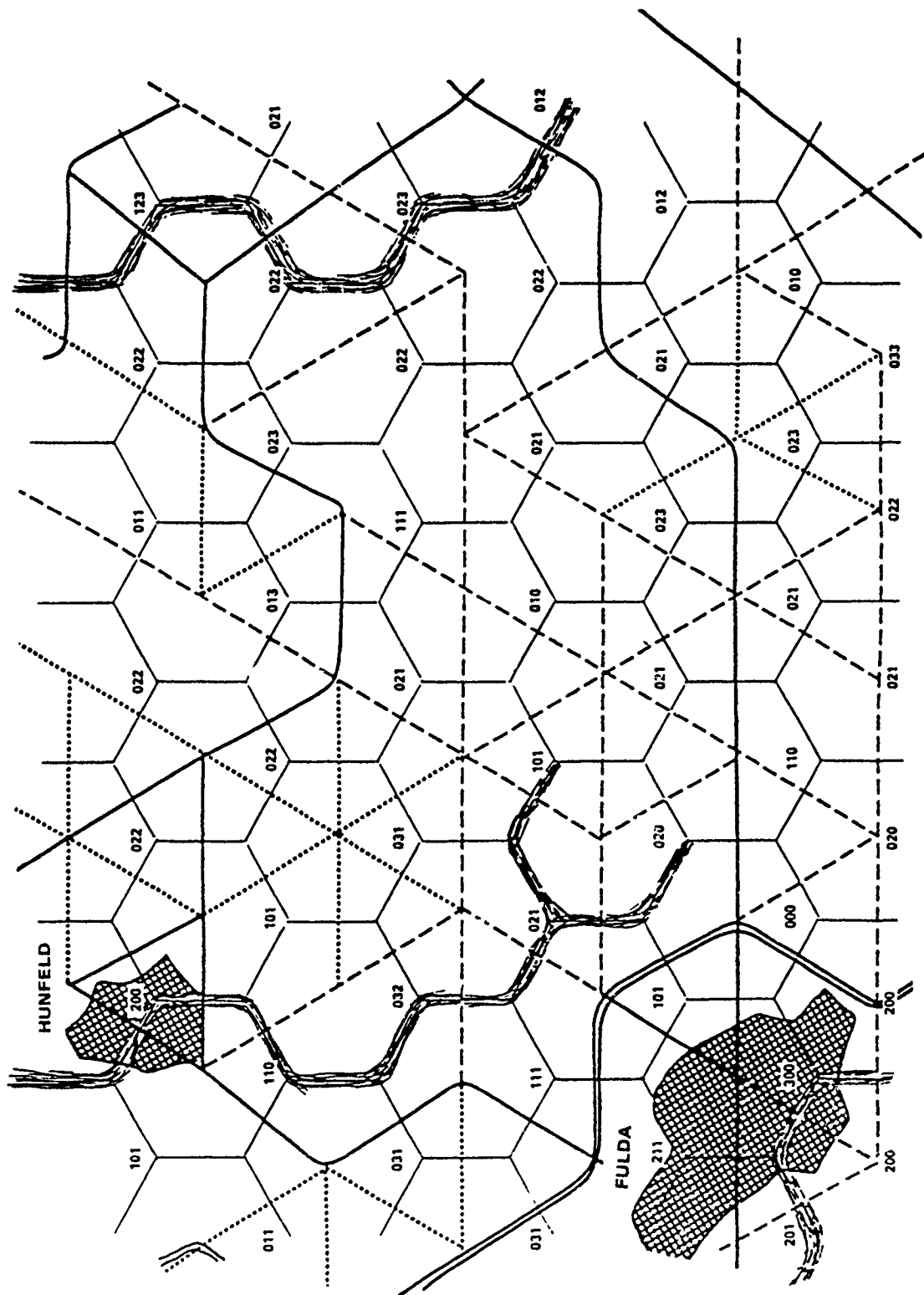
Figure 2-5. Sample ICOR Terrain

fire. The attrition is assessed for each unit fired on. Note that this is a unit-oriented rather than engagement-oriented system. Each unit decides for itself whether it will remain in combat or attempt to disengage based on predefined "breakpoints" or other decision criteria using the Operation Reaction System (ORS).

2.2.1 MOVEMENT

Each unit weights its decision on how to move toward the objective stated in that unit's operations order. Weighting factors include terrain trafficability, cover, road structure, relative massing of forces, perceived location of threat forces, and organizational cohesiveness. These weighting factors, and other parameters affecting the unit's operation, are determined by the unit's operation code, also contained in its operation order. A unit's mission code is what it is ordered to do; its operation code is what is is forced to do by the circumstances.

Other operation dependent parameters can be used to define certain minimum terrain requirements. For example, a given operation may prohibit movement through forestation or mountainous terrain of degree 3 in the absence of a road. Operations may also have specified a number of hexes of 'look ahead' which they consider in the movement decision.

2.2.2 GROUND MANEUVER UNIT "OPERATION CODES"

ICOR utilizes a finite set of states to represent a unit's operation, its posture, and its situation. These states, in turn, influence the unit's immediate combat capabilities. For example, a unit in a prepared defense would be able to defend better than a unit in a hasty defense, receiving fewer casualties from and inflicting greater losses on an attacker. Since the unit in a hasty defense would have less time to set up barriers and mutual defense positions, it would be more easily dislodged and more threatened by a flanking situation. These unit states are defined by the operation code, some of which are briefly described as follows:

(0) Prepared Defense: the posture of a unit that has been in place, and out of contact, for sufficient time to "dig in," erect barriers, etc. (The model allows this time to be a function of

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available combat support, such as combat engineer support; in current analysis applications, however, only those units in their initial main battle area positions are assumed to be in this posture.)

(1) Hasty Defense: the basic defensive posture in unprepared positions.

(2) Delay: trading space for time, avoiding decisive engagement.

(3) Withdraw: attempting to break contact.

(4) Hasty Attack: basic attack posture.

(5) Flanking Attack: avoiding frontal attacks, maneuvering to flanks before closing with opposing unit(s).

(6) Breakthrough: allowing considerable massing of forces, deliberate in direction of attack, accepting relatively high attrition rates.

(7) Holding Attack: engaging opposing units, but avoiding close combat when possible.

(8) Close Combat: an existing situation, versus an "order," reflecting the attrition and movement associated with attacking and defending units in close proximity.

(9) Reconnaissance: forward movement, bypassing known opposing force positions, avoiding combat when possible.

(10) Road Movement: non-combat movement, attempting to maximize use of available road network.

(11) Logistics/HQ: this operation code is used for headquarters and logistics units in stationary potiions.

(12) Move: used by moving artillery units only.

(13) Move and Shoot: this operation code represents a combination of movement and firing by different components at the unit, so that some battery will always be able to fire, but the unit as a whole moves (albeit more slowly than with code 12).

(14) Shoot: stationary artillery in firing positions.

(15) Convoy: used for moving logistics and headquarter units.

(16) In different applications: inactive defense or river crossing operation.

Additional types of operations can be defined by the user by entering the parameters necessary to describe the manner in which that operation causes the unit to move and fire, break contact, and change missions, all as defined by the ORS.

Operation orders, each containing an objective and mission code, can be linked together to define, for a given unit, a sequence of operations. Thus, when the first objective is reached, the second operation order becomes effective. It is also possible to give a unit a "follow" operation order which specifies for a location a variable offset from some other unit as an objective, so that as the other unit moves, so does the objective, and hence the following unit. This is particularly useful for logistic and artillery support units.

2.2.3   DIRECT FIRE ATTRITION

Combat attrition is similarly impacted by a number of operation dependent factors. In the methodology, the representation of combat attrition is based upon a Lanchester "square-law" model and is calculated for each weapon type available and modified by situational factors. These situational factors include unit posture and disposition as defined by the unit's current operations order, current unit strength (losses), terrain cover and concealment, available weapons and their effectiveness against specific targets as a function of range and the influence of suppressive fires.

Attrition modeling typically accounts in detail for the effects and capabilities of various weapons, but seldom includes a mechanism to account for organizational or other limitations on weapon use. The ICOR treatment of direct fire attrition, however, allows a unit's effective firepower to be modified as a function of its disposition, the weapon effective range, and important effects.

The basic attrition algorithm as shown in Figure 2-6 can be used to determine the change in the number of individual target weapons for each specific type of weapon modeled. The kill rate, "K," is expressed in terms of the effectiveness of each weapon type against each opposing weapon

DIRECT FIRE
ATTRITION ALGORITHM

$$\Delta X = K \bullet A/D \bullet d_f^{(m-1)} d_t^{(n-1)} \bullet T_C \bullet S \bullet N \bullet \alpha$$

ΔX	=	ATTRITION OVER TIME INTERVAL (M-60 ON T-62, TOW ON T-62, DRAGON ON T-62, ETC.)
K	=	KILL RATE (RANGE DEPENDENT)
A/D	=	ATTACKER-TO-DEFENDER "MATCHUP"
$d_f^{(m-1)}$	=	WEAPON DISPOSITION FUNCTION,

d_f = f(OPERATION "CODE")
m = f(WEAPON RANGE, TERRAIN)

$d_t^{(n-1)}$	=	TARGET UNIT DISPOSITION FUNCTION,

d_t = f(OPERATION "CODE")
n = f(TERRAIN)

T_C	=	TERRAIN COVER & CONCEALMENT FUNCTION
S	=	SUPPRESSION FACTOR (WEAPON & TARGET DEPENDENT)
N	=	NUMBER OF WEAPONS
α	=	FIRE ALLOCATION OVER TARGET ARRAY

Figure 2-6. Direct Fire Attrition Algorithm

type and is dependent on the weapon's range capabilities. The attacker-to-defender "matchup" factor is related to the operational status for each side; the value of "A" is governed by the firing opportunities available to the attacker, and "D" varies according to the defensive advantage of being in prepared or unknown positions as determined by the operation code of the respective units. This allows, for example, the distinction in battle outcome when a hastily attacking unit engages an opposing unit in a prepared defense versus a hasty defense. The 'normal' D is 1 for attack operations; the 'normal' A is about 1 for defense operations

The disposition factor "d" in the weapon disposition function describes the ability of the unit to bring weapons to bear on targets and is a function of the unit's operational mission. The value of "m," the echelon effect factor, is a function of either the weapon range or the local terrain range visibility limitation, whichever is most limiting. The weapon disposition factor is used to account for situations where the full firepower of a maneuver element cannot be brought immediately to bear on an opposing force. This occurs, for example, in a meeting engagement when two moving forces initially come into contact. A similar term takes into account the terrain and disposition effects of the target unit. The terrain cover and concealment function allows for the effects on attrition of forests, towns, rivers, highway use, etc.; "T_c" is a function of the hex in which the unit is located. "S," the suppression factor, allows for suppression effects on the firing weapon and is, therefore, dependent on both the weapon and target. The number of firing weapons is determined by "N," and, finally, "a" represents the allocation of fire by each weapon type to each unit and weapon within the target array.

Note that since this is basically a Lanchester square law mechanism, its results do not consider target scarcity. If units with small numbers of assets are fired upon, their attrition would tend to be too large.

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2.2.4   SUPPRESSION METHODOLOGY - DIRECT FIRE

Once the direct fire attrition of one system versus an opposing system has been determined, it is adjusted for suppression conditions based on the particular conditions at the shooter's location. This adjusted or degraded capability is then utilized in casualty assessment for the maneuver units in contact during that time interval. The adjustment of a particular kill rate of a weapon system versus another is dependent on the intensity or amount of incoming fire against the parent unit as well as the susceptibility of the firing weapon to suppression. This latter factor is called the "weapon suppression scale factor" in Figure 2-7. It is the means which permits different weapons such as tanks and man-packed Dragons to be affected differently by incoming fires.

2.2.5   THE UNIT DECISIONMAKING PROCESS

The scope of the C^2 hierarchy in ICOR is from division or corps through battalion headquarters. The echelons above battalion are simulated by the MITL mode, with status reports, intelligence reports, CAS requests, etc., provided to the human commander, who then integrates information, plans, and develops operations for the units. Orders are generally given to the battalion automated players through specification of objectives and missions (OPORDS). The battalion, through the mechanism of the ORS (for details see the following pages), acts and reacts according to specific orders as well as to current doctrine reflected in the ORS. The battalion units can react to situations (e.g., threat of being flanked) by transitioning from one operation to another, depending on circumstances, without losing sight of their overall specified mission and objectives. TACAIR, attack helicopters, and sensor tasking are performed explicitly by the MITL.

Figure 2-8 illustrates the performance of the Operation Reaction System. As a preliminary step, the unit using the ORS must evaluate its situation based on the effects of combat and movement up to that time. This results in a set of situation components, including separate indications of contact with enemy units, danger of being flanked, own casualty or supply status, meeting engagement conditions, combat status, etc. To

SUPPRESSION METHODOLOGY — DIRECT FIRE

$$\Delta X'_{ij} = \Delta X_{ij} \times E(-SLVL_i \times WSUP_i)$$

$$=$$

WHERE:

$\Delta X'_{ij}$ = ATTRITION OF j BY i

ΔX_{ij} = POTENTIAL ATTRITION

$SLVL_i$ = INTENSITY OF INCOMING FIRE DURING LAST COMBAT INTERVAL
    FOR SHOOTER i

$WSUP_i$ = WEAPON SUPPRESSION SCALE FACTOR FOR WEAPON ·

· WEAPON i CAN INCLUDE DIRECT OR INDIRECT FIRE SYSTEMS.

Figure 2-7. Suppression Methodology - Direct Fire

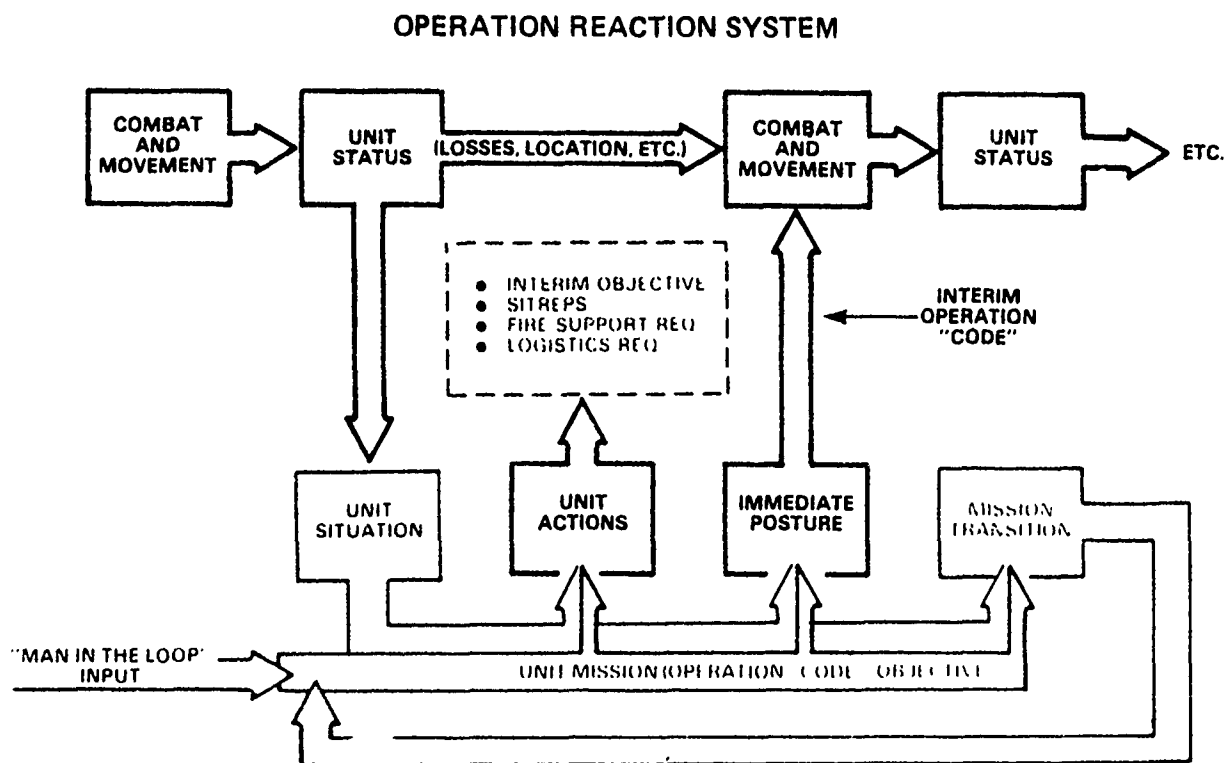## OPERATION REACTION SYSTEM

Figure 2-8. Operation Reaction System

reduce table sizes, similar combinations of these input unit status variables are reduced to single-number situation codes, which are then used as input to the action, operation, and mission transition tables.

As shown in the bottom half of the figure, the unit situation codes and the mission codes from the unit's current operation order are used as inputs to the three tables in the ORS. The first table is used to look up a unit action code, which may specify generation of a new interim objective, requests for additional support, etc. The second table gives an interim operation code which determines the parameters affecting combat, movement, and situation evaluation for the next cycle of the physical process. The third table, mission transition, may yield a new mission code to replace the previous code, although in many cases they will be identical.

2.3   ARTILLERY MODEL

Artillery operations are generally modeled at the battalion level, the lowest unit typically treated in the simulation. Exceptions to this generalization are the non-divisional armored cavalry squadrons, where the organic artillery batteries are explicitly played and located. Another example is the Multiple Launch Rocket Systems (MLRS) which are normally employed in platoons, and are modeled and explicitly represented at the platoon level of detail. Even though the artillery firing unit itself is not explicitly represented, the internal battery operations are modeled at the firing unit level. See Figure 2-9. For example, the "firing unit" for the 155mm Howitzer is a four-gun platoon. There are six "firing units" in the figure. Three are firing, one is displacing to a new firing position. Only one is inactive or available for a fire mission. This illustrates the level of resolution in the internal modeling of the artillery battalion in ICOR. Statistics are kept for the number of firing units in the battalion that are firing, moving, or suppressed, and damages are assessed on a firing unit basis.

Indirect fire takes place when a field artillery unit receives a request for fire from a maneuver unit, or when acquisition assets acquire a target of an appropriate type which satisfies a man-in-the-loop input set
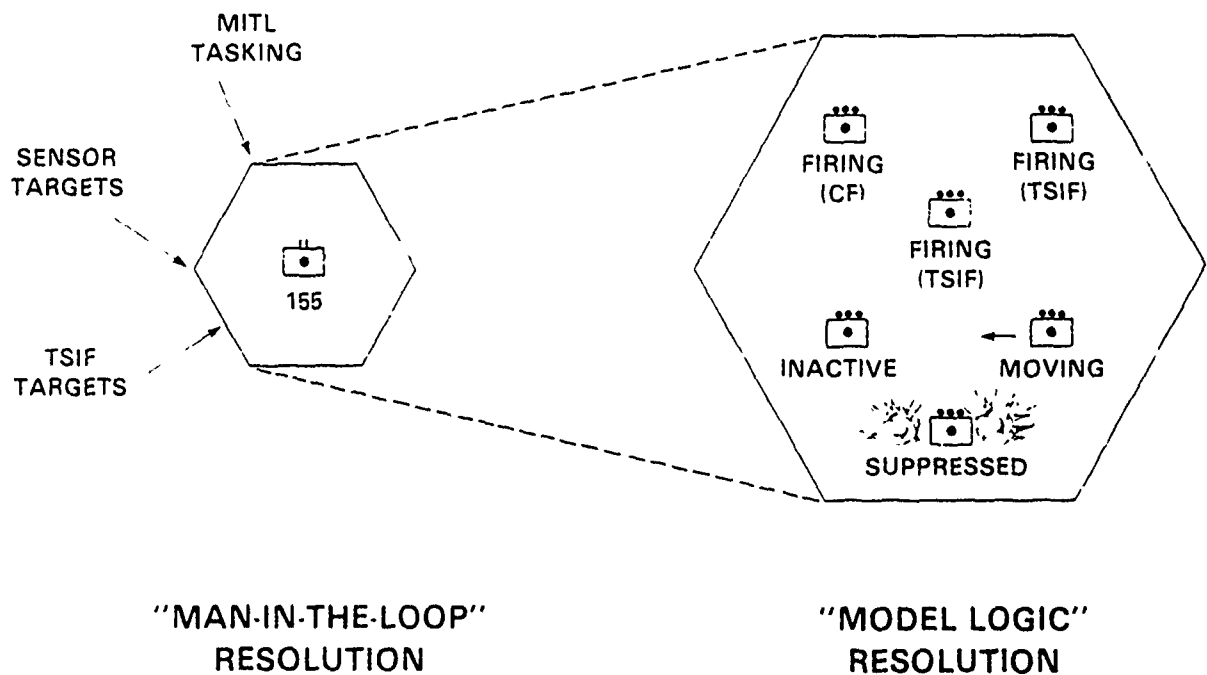
FIRING UNIT RESOLUTION
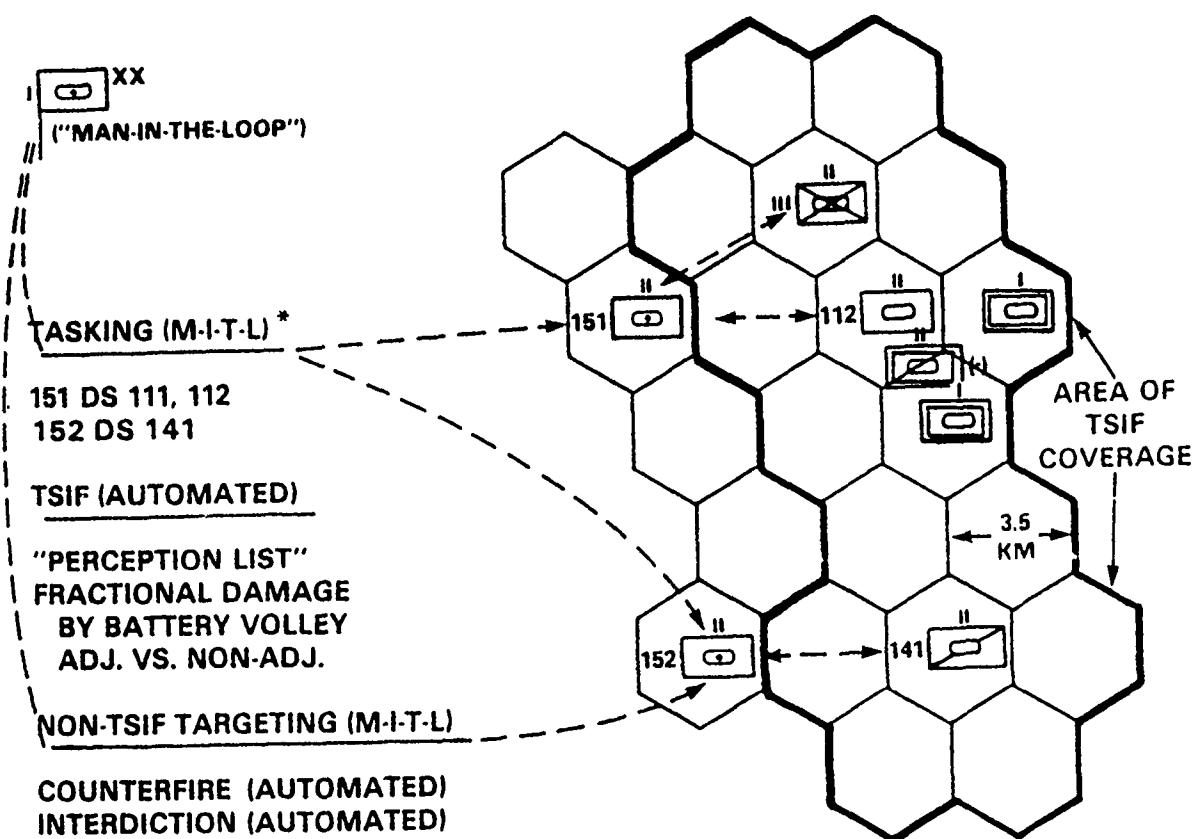

Figure 2-9. Firing Unit Resolution

of engagement rules. The effects of indirect fire fall into three categories: attrition, suppression, and delay. Attrition calculation is dependent on the type of munition. Four classes of munitions are available in ICOR: dumb, smart, mine, and nuclear munitions. Dumb munitions attrition are normally calculated in terms of fractional damage coverage of a standard target that is modified depending on the target unit's disposition and current activity. The attrition associated with precision guided munitions, such as COPPERHEAD, is determined on an expected kills per volley basis. Some munitions such as smoke have only suppressive effects, which degrade the effectiveness of the target unit's fire or its rate of fire, whichever is appropriate, and also may degrade movement. Other munitions such as FASCAM have delayed attrition effects that are activated only when the target unit comes in contact with them. The immediate effects of indirect fire are assessed at the end of each volley of fire by the user-defined firing unit (such as one MRS launcher, or a four-gun platoon.)

The following discussion describes the individual missions normally associated with the artillery as they have been modeled in ICOR. These missions include target servicing indirect fire (TSIF), counterfire (CF), interdiction (BI), and suppression of enemy air defenses (SEAD). The latter capability requires explicit representation of air defense units. The last two charts in this section deal with the methodology for assessing casualties caused by artillery and the effects of artillery in suppressing opposing artillery systems.

2.3.1   ARTILLERY MODELING (TARGET SERVICING INDIRECT FIRE)

Figure 2-10 deals with target servicing indirect fire (TSIF). This type of fire is any fire in support of a unit in contact. It is akin to the direct support (DS) mission of the artillery since artillery units with a DS mission will be heavily involved in delivering TSIF fires. The initial TSIF tasking to the battalions is done by the man-in-the-loop and is comparable to simplified operations order given to a battalion. In the example shown here, the MITL initially gave an operations order to battalions 151 and 152 by assigning 151 to a mission of direct support of the

ARTILLERY MODELING (TSIF)

XX
("MAN-IN-THE-LOOP")

TASKING (M-I-T-L) *

151 DS 111, 112
152 DS 141

TSIF (AUTOMATED)

"PERCEPTION LIST"
FRACTIONAL DAMAGE
  BY BATTERY VOLLEY
  ADJ. VS. NON-ADJ.

NON-TSIF TARGETING (M-I-T-L)

COUNTERFIRE (AUTOMATED)
INTERDICTION (AUTOMATED)

151

112

152

141

AREA OF
TSIF
COVERAGE

3.5
KM

*DS UNITS CAN ALSO BE TASKED TO REINFORCE OTHER
ARTILLERY UNITS AS NEEDED. IN THIS ROLE THEY MAY FIRE
COUNTERFIRE OR INTERDICTION INSTEAD OF TSIF.

3856A/80W

Figure 2-10. Artillery Modeling (TSIF)

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111 and 112 maneuver battalions and 152 to a similar mission in support of 141. This means that requests for fire from the 111 and 112 maneuver battalions would go back to the 151 unit, as indicated by the arrows in Figure 2-10. Battalion 151 would respond only to those battalions and would prioritize its fires according to the threat of the targets. This prioritization of available fire assets is done on a routine basis when requests exceed capabilities by means of a threat index which weights the opposing units' combat strength, weapon systems, and disposition to determine the overall threat.

This target generation and request system is engaged automatically in the model. For example, battalion 112 in the Figure perceives he is opposed by three Red maneuver elements including a tank battalion (minus) and two tank companies (the actual threat force may be greater). Those three units are automatically placed on the target list for artillery unit 151 without any MITL processing. The three units would then be prioritized as previously mentioned, and various firing batteries in 151 would be assigned to fire on the targets. Targets out of range of 151 would not be fired upon. Damage and suppression is assessed after each volley as a mission is fired. The attrition calculation is discussed later.

2.3.2   ARTILLERY MODELING (COUNTERFIRE)

The General Support (GS) and General Support Reinforcing (GSR) mission have a number of specific responsibilities. Two of the more important ones are counterfire and interdiction. Figure 2-11 illustrates the counterfire mission. If the MITL assigns a counterfire mission to a particular battalion, a fire fan will be specified. This fan provides the orientation of the battalion countermortar/counterbattery (CM/CB) radars. The area highlighted in Figure 2-11 is an example of CM/CB radar coverage used in the model. The radars are periodically turned on according to an on-off doctrine specified in the input. When they turn on, they assess the area of coverage to determine if any opposing artillery batteries are firing. If some opposing artillery batteries are firing, a calculation is made to determine whether they would be detected and whether the detection

ARTILLERY MODELING
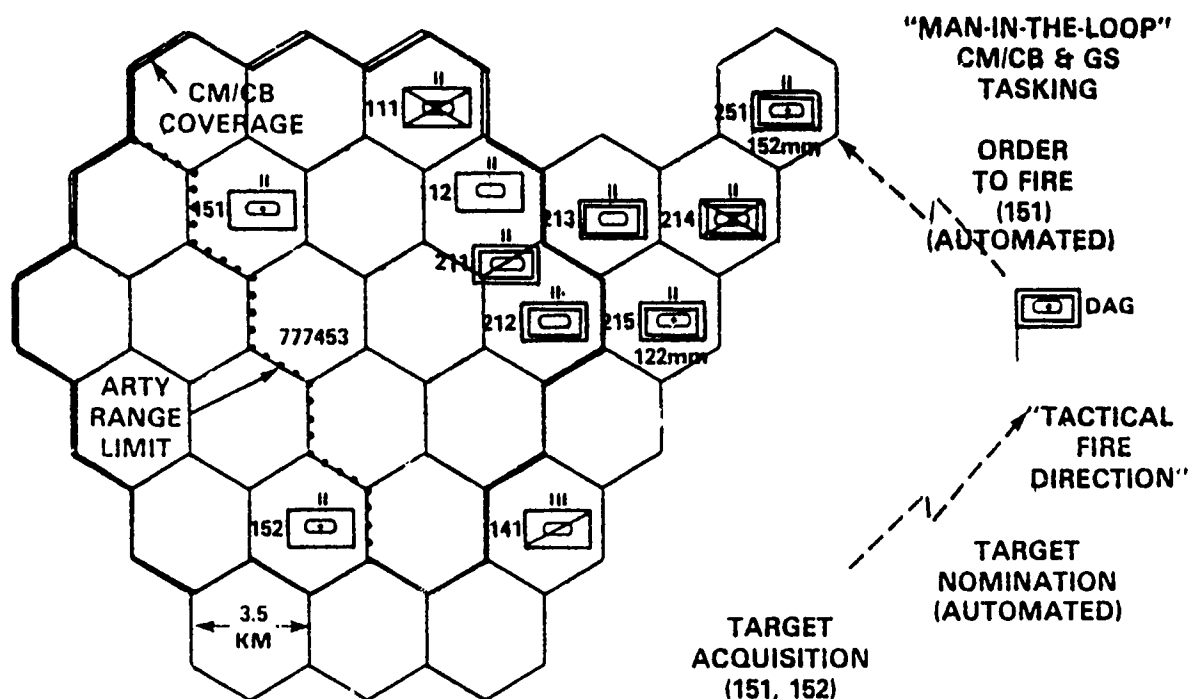
(COUNTERFIRE)

3856A/80W

Figure 2-11. Artillery Modeling (Counterfire)

would be accurate enough for targeting purposes. After detection is ascertained, the particular targets are placed on a target list for firing. As a firing battery becomes available, the mission is fired. The periodic radar assessments, acquisition, targeting and firing are accomplished automatically in the model. The example depicted is illustrated from the Red side. Red artillery battalion 251 is assigned a CF mission. Its sector is as outlined. If Blue units 151 and 152 are both acquired, they are put on a target list for Red artillery battalion 251, which in turn assigns its batter'es to fire. As is done with TSIF, a range calculation is made to determine if the weapon systems are in range of the targets. In the case illustrated, 152 is not in range and would be removed from the target list. Damage and suppression is assessed on a volley by volley basis.

2.3.3   ARTILLERY MODELING (INTERDICTION)

In the case of interdiction, general support artillery battalions are normally assigned to engage targets automatically processed from sensors that satisfy MITL engagement criteria. For all three types of artillery modeling, the MITL can augment or override the system and assign specific targets to specific firing units, but this specific target tasking is most common for interdiction. In Figure 2-12, for example, four missions are indicated to demonstrate the types of targeting that can be done through MITL or a sensor. First of all, mines can be delivered against specific hex sides in order to mine a road as depicted in hex 777511. Also fire can be delivered at suspected enemy locations such as in the second fire mission, which calls for eight battery volleys of HE at location 777442. A third interdiction mission is on-call fires, in which a location is given, but the fires are not delivered until a potential target moves into that location. An example of on-call fires could be a tank unit moving down a road. When it reaches a preplanned location, the artillery is automatically fired. Finally, SEAD (suppression of enemy air defense) can be played explicitly by firing artillery at air defense units acquired by modeled ELINT systems (target effect includes consideration of sensor target location error).

ARTILLERY MODELING (INTERDICTION)

"MAN-IN-THE-LOOP"
TARGET NOMINATION

SENSOR DERIVED
TARGET NOMINATION
(AUTOMATED)

"MAN-IN-THE-LOOP"
TACTICAL FIRE DIRECTION
(AUTOMATED)

MISSIONS:
(1) ARTY DELIVERED MINES, 777511 (161)
(2) 8 BATTERY VOLLEYS, HE, 777442 (161)
(3) 2 BATTERY VOLLEYS, ON CALL, 777511 (171)
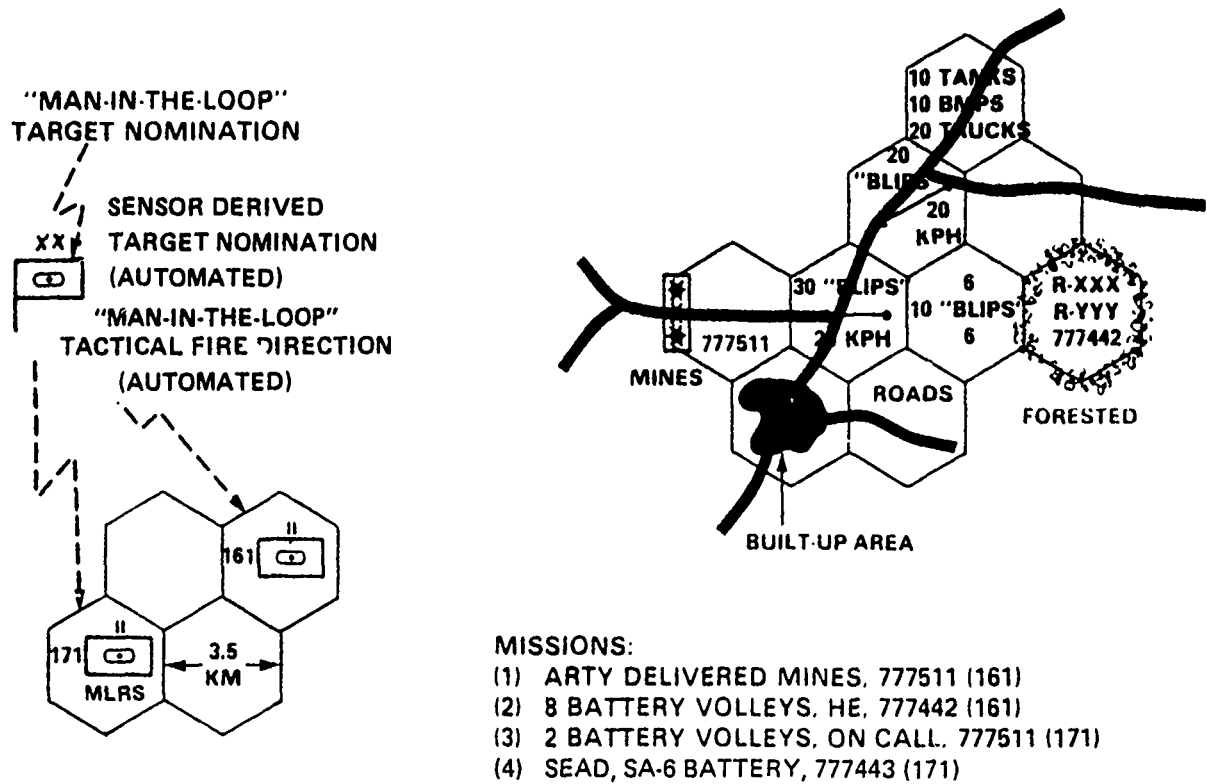(4) SEAD, SA-6 BATTERY, 777443 (171)

Figure 2-12. Artillery Modeling (Interdiction)

2.3.4 INDIRECT FIRE ATTRITION

Indirect fire attrition is basically a much simpler calculation than direct fire attrition because individual volleys are fired obviating the need to convert to a kill rate. Figure 2-13 gives the equation for "dumb" or area munition attrition. In determining attrition due to indirect fire weapons, the strength ratio of the firing unit is calculated by dividing the remaining number of tubes by the initial number. This factor is multiplied by the overall fractional damage value for the firing unit against a specific type of weapon in the targeted unit and by a target density factor. This value is subtracted from one to give the fraction expected to survive, which is then multiplied by the number of (targeted) weapons prior to the attack. The end result is the number of surviving weapons in the targeted unit after the attack. The "target density factor" adjusts the resulting losses to reflect different operational postures that change the effectiveness of the weapon. Typically, this compensates for the different target densities within the impact area inherent with, for example, a unit in an assembly area versus one participating in a breakthrough operation.

2.3.5 SUPPRESSION METHODOLOGY - INDIRECT FIRE

The ICOR modeling of indirect artillery fire includes a capability to play suppression of both direct and indirect fire assets. The direct fire suppression methodology was discussed earlier. The equation for the artillery is shown in Figure 2-14. The artillery batteries can be suppressed in a fashion similar to the suppression of direct fire assets by artillery. The method in which this is implemented differs. As mentioned previously, artillery batteries/platoons in ICOR actually fire individual volleys against specific targets. As such, the effect that incoming artillery fire has on opposing artillery batteries is to lengthen the time it takes to fire the next volley. For example, an artillery battery that is capable of firing one volley a minute but is now receiving counterbattery fire may be capable of firing only one volley every two or three minutes. This latter example is meant to be illustrative only and should not be interpreted as the actual effects of counterbattery. In fact, the actual suppressive effects depend on a number of variables as shown in the figure.

INDIRECT FIRE ATTRITION

$$WPN_J = \#WPN_J \times \left(1 - \left(\frac{TR_i}{IT_i} \ FD_{iJ}\right) \times \left(TDF\right)\right)$$

WHERE:

WPN$_J$ = WEAPONS OF TYPE J REMAINING IN TARGETED UNIT

#WPN$_J$ = NUMBER OF WEAPON J PRIOR TO ATTACK

TR$_i$ = NUMBER OF TUBES OF TYPE i REMAINING IN FIRING UNIT

IT = INITIAL NUMBER OF TUBES

FD$_{iJ}$ = FRACTIONAL DAMAGE OF i ON J

TDF = TARGET DENSITY FACTOR IS F (OPERATION AND TARGET BEHAVIOR)

Figure 2-13.   Indirect Fire Attrition

SUPPRESSION METHODOLOGY— INDIRECT FIRE

$$FT = \frac{1}{FR} \left[1 + LSL \left(1 - E \ \frac{-WSUP \times SLVL}{N}\right) \right]$$

WHERE:

FT = TIME OF NEXT VOLLEY

FR = FIRING RATE OF BATTERY, I.E., MAX OR SUSTAINED

WSUP = WEAPON SUPPRESSION SCALE FACTOR

SLVL = INTENSITY OF INCOMING FIRE DURING LAST FIRE INTERVAL

LSL = LENGTH OF SUPPRESSION LIMITER

N = NUMBER OF BATTERIES FIRING

Figure 2-14.   Suppression Methodology-Indirect Fire

These include the amount or intensity of the incoming fires, the unsuppressed firing capability of the particular type of artillery battery or platoon receiving the fire, as well as the susceptibility of that particular type of artillery to counterbattery fires. The latter scaling factor (WSUP) allows for suppressive effects against towed artillery to be different from effects on self-propelled artillery or open-carriaged tracked artillery. The length of suppression limiter (LSL) is the maximum period of time that an artillery unit will allow itself to be suppressed; after that time interval, it will displace to a new firing position.

2.4   NUCLEAR OPERATIONS

The ICOR simulation has the capability to play all the nuclear delivery means currently available. These include cannon, missile, and aircraft delivery systems for both sides. Thus for the Blue force, nuclear delivery means such as 155mm, 8" artillery, Lance, Pershing, and all types of tactical aircraft are modeled.

In addition to the delivery means, the actual warheads (missiles, rounds or bombs) are represented. They are categorized by type of delivery weapon and yield. For those warheads which are intended for Army use by cannon or missile units, the forward nuclear logistic network is represented. This includes the forward nuclear supply points and the movement of warheads to the firing units by convoys. Nuclear warheads are expended by an artillery unit in firing a nuclear mission, by a missile unit in launching a nuclear strike, and by an aircraft in carrying out a nuclear sortie. Each nuclear warhead that is expended by one of these means is accounted for by yield.

The effects of nuclear detonation on targeted elements are in terms of user defined casualty criteria such as prompt casualties from blast or radiation. The effects consider a number of factors: the yield of the weapon, the target type and posture, the equipment type, the target location error, and the delivery accuracy and range from the delivery means. In one application study using ICOR, immediate transient incapacitation was used for determining the casualty effects.

Unlike the automated targeting for conventional missions, all the nuclear target selection is accomplished by the Blue and Red commanders -- the man-in-the-loop (MITL) for each side (Figure 2-15). The target selection by these individuals is primarily based on the existing information concerning enemy and friendly forces, the strategy for nuclear employment, and the operational plans for subsequent combat. The enemy situation is based on the intelligence that has been acquired by the sensors as well as from friendly maneuver units. Each target that is nominated by the man-in-the-loop is specified by the desired coordinates for ground zero (hex location), the mode of delivery, the firing unit for an artillery delivered weapon, and the yield. This manual method of target selection is appropriate for the division and corps level where only a few weapons (20-40) might be used in any single pulse.

After the targets are selected and provided as input, the model makes some final checks to ensure that the guidelines that were stated for use of nuclear weapons are not violated. These are concerned with minimum safe distance for friendly troops and preculsion damage criteria for built up areas. The casualty effects are based on the radius of damage for the yields of the weapons in question for the category of effects used and the type target. FM 101-31 series can be used as the source of the information for non-enhanced radiation weapons. Appropriate laboratory listings can be the source for radii of damage for the enhanced radiation weapons. Depending on this radius, the size of the targets, and the number of targets in the vicinity, bonus damage can be assessed.

As mentioned above, the effects methodology used in ICOR allows for the consideration of targets' postures. Figure 2-16 depicts an example of this. An armored battalion located in a hex may be disposed over target areas of quite different sizes depending on the current operation. First, a battalion might be in an assembly area deployed over an area of 500 to 1,000 meters in radius. It could be in a road march and disposed like a snake over an area, 15 meters wide by 5,000 meters long or it could be deployed for combat over a 1,000 meter wide front by 800 meter depth. Obviously the effectivess of a nuclear detonation will vary depending on the posture of the target.

METHODOLOGY FOR NUCLEAR ENGAGEMENT

- TARGET SELECTION
  - NOMINATED BY MAN-IN-THE-LOOP
  - SPECIFIED BY LOCATION AND YIELD

- TARGET ENGAGEMENT
  - CONSIDERATIONS
    - MINIMUM SAFE DISTANCE FOR FRIENDLY TROOPS
    - COLLATERAL DAMAGE
  - EFFECTS MANIFESTED AS FRACTIONAL DAMAGE TO TARGETS BASED ON FM 101-31 SERIES DATA
  - BONUS DAMAGE FOR INTER/BATTALION WEAPONS

Figure 2-15. Methodology for Nuclear Engagement
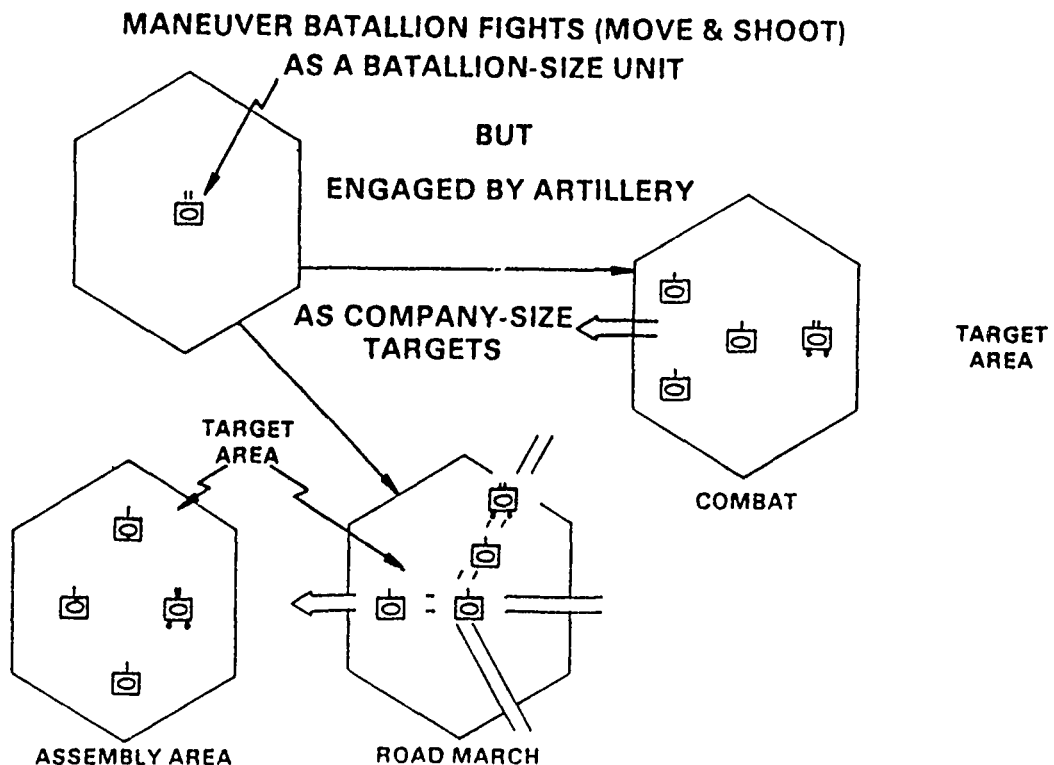
NUCLEAR TARGETS

MANEUVER BATALLION FIGHTS (MOVE & SHOOT)
AS A BATALLION-SIZE UNIT

BUT

ENGAGED BY ARTILLERY

AS COMPANY-SIZE TARGETS

TARGET AREA

COMBAT

TARGET AREA

ASSEMBLY AREA

ROAD MARCH

Figure 2-16. Nuclear Targets

2.5 AIR SUPPORT OPERATIONS

The ICOR air support operations modules currently feature two primary support missions, close air support (CAS) and air interdiction. Through the judicious MITL assignment of the air penetrators, various interdiction missions may be accomplished. The flights operate from a notional tactical air base, which generates CAS sorties and penetrator missions at a user-specified rate commensurate with different aircraft launch rates or generates sorties on a predetermined schedule of aircraft availability. These missions are flown by any number of types of user-specified aircraft. Figure 2-17 below lists the aircraft and helicopters currently defined in existing data. Other types of aircraft can be defined very simply by the user. Each aircraft has times associated with rearming refueling, and speed, thus influencing its availability. Attack helicopters are played in a similar fashion, accounting for their unique employment and support characteristics.

CURRENT AIRCRAFT TYPES*

HIND-D		AH-64	
FISHBED-J		A-10	
FLOGGER-D		F-4	
RAM-J		F-16	
FRS.1 (HARRIER)		F-111	
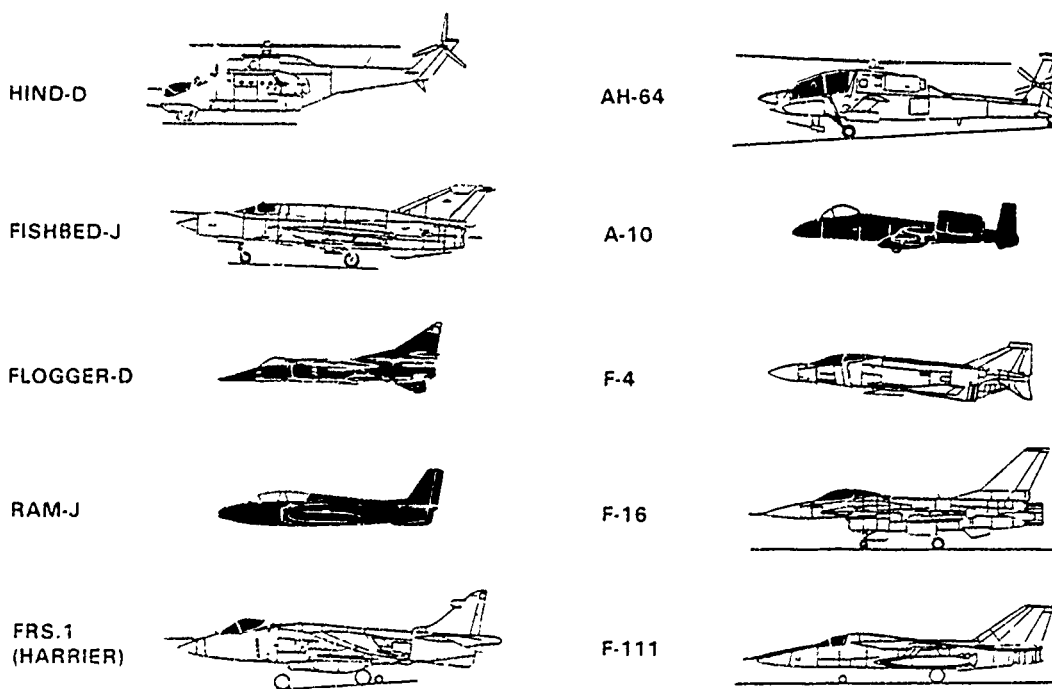
*USER CAN DEFINE OTHER AIRCRAFT TYPES

4811 HOW

Figure 2-17. Current Aircraft Types

38

2.5.1   AIR DEFENSE ATTRITION

In ICOR, aircraft are subject to attrition from air defenses as they fly their missions. The air defense systems for the Red force currently defined in ICOR for previous applications include the following:

(1) Anti-Aircraft Guns

    (a) ZSU-23-4

    (b) ZSU-23-2

    (c) ZSU-Follow On

(2) Surface-to-Air Missiles

    (a) Radar Guided

        ● SA-4

        ● SA-6

        ● SA-8

        ● SA-11

    (b) Infrared

        ● SA-7

        ● SA-9

The model is not limited to these weapon systems since the user can define others.

The air defense attrition in ICOR can be calculated in an implicit fashion parametrically on a per sortie basis or use explicit ground-to-air interactions between the systems listed above and the flights of aircraft. Figures 2-18 and 2-19 highlight these two very different techniques for attriting aircraft. The selection of the option to be used is left completely to the user. The explicit air defense representation requires much more data and also puts more demand on the machine used. It, however, allows gamers to concentrate their air defense assets in areas of high priority and have that concentration affect the battle. The explicit and implicit air defense representation can be mixed by side. Thus, Red air defense can be played explicitly while Blue air defenses are represented implicitedly. The complement of that is also possible.
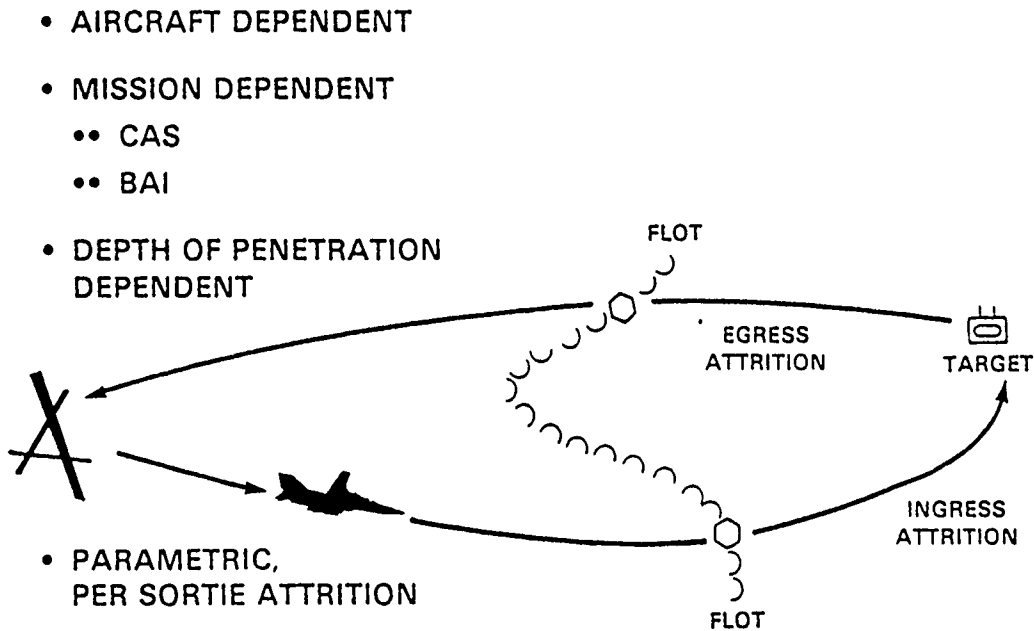
IMPLICIT AIR DEFENSE

- AIRCRAFT DEPENDENT

- MISSION DEPENDENT
  - •• CAS
  - •• BAI

- DEPTH OF PENETRATION
  DEPENDENT

- PARAMETRIC,
  PER SORTIE ATTRITION

FLOT

EGRESS
ATTRITION   TARGET

INGRESS
ATTRITION

FLOT

Figure 2-18. Implicit Air Defense

EXPLICIT AIR DEFENSE OVERVIEW

GROUND EXPOSURE ► ALTITUDE DEPENDENT

WEAPON LIMITATIONS ► AD WEAPON RANGE
& ALTITUDE (MIN & MAX)

PROBABILITY OF LINE
OF SIGHT ► MASK ANGLE

SA-8

ZSU 23 4

SA-6

SA-o
RANGE

SA 4
RANGE

ENGAGEMENTS ► DEPENDENT ON AD
SYSTEM CAPABILITIES
AND STATUS, AND
AIRCRAFT PARAMETERS

A/C ATTRITION ► # OF ENGAGEMENTS BY TYPE
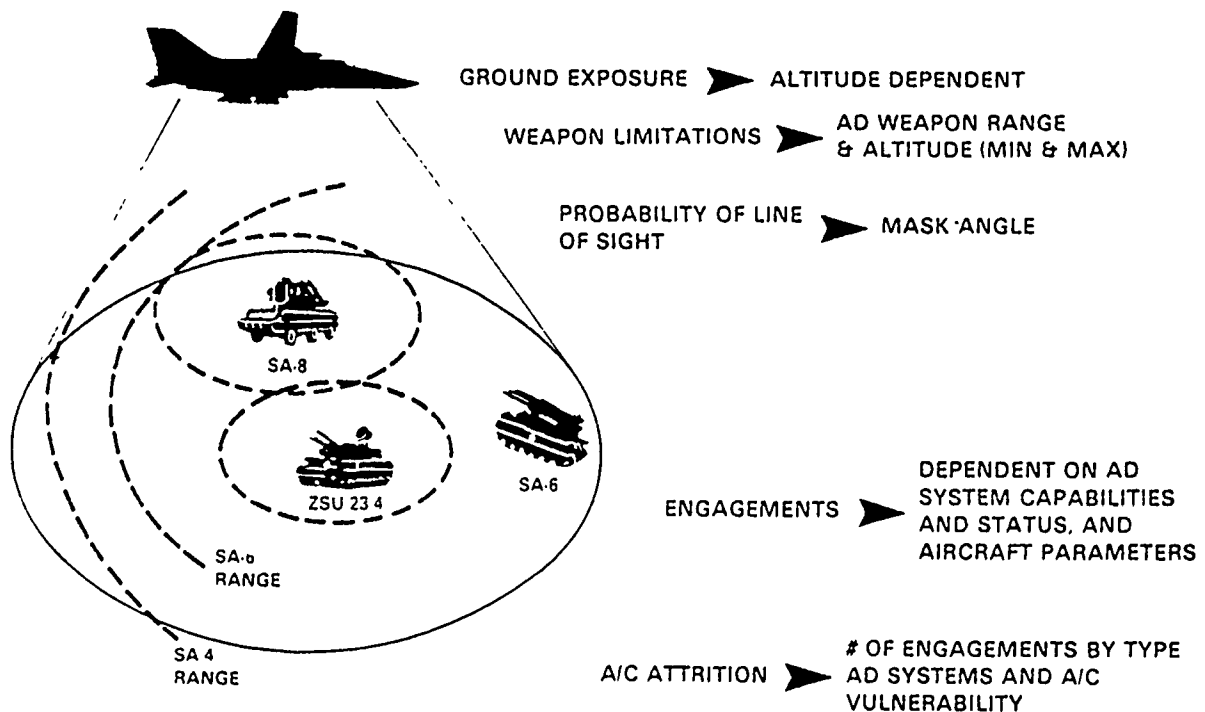AD SYSTEMS AND A/C
VULNERABILITY

Figure 2-19. Explicit Air Defense Overview

40

The explicit air defense treatment in ICOR is, obviously, not at the level of resolution of a "fly out" model like the TAC-ZINGER family or TAC-RAPELLER models are. However, it does represent the mechanics associated with preparing to engage, engaging, reloading, and the effects of movement on a system's capability to engage. Figure 2-20 depicts the activities modeled in ICOR that describe the explicit nature of the air defense representation. Any engagement is initiated by an acquisition of a flight by some early warning radar or visual means. When the flight is in range and altitude constraints of the particular air defense system in the unit, the system reacts to the potential target. This takes a discrete time interval after which the air defense unit can fire or engage. In this engagement, the air defense unit is limited to the number of missiles on the rails at the time of engagement. After "firing out," the air defense unit reloads before it can engage for subsequent firings. In this reloading, the basic load for a particular type system is considered and it is possible that no round/missiles are available without a resupply.

The actual attrition that results from an engagement is calculated using the equation in the following Figure 2-21. The factors that influence the attrition of a flight to an air defense weapon in a specific unit are the single shot probability of kill of that system versus that aircraft type, the number of engagements that the air defense weapons in the specific unit could obtain using the methodology described above in Figure 2-20, as well as the number of aircraft in the flight.

2.5.2 DIRECT AIR SUPPORT MODELING

Based on SITREPs, "line-of-contact" intelligence, sensor reports, and intelligence preparation of the battlefield, the man-in-the-loop commander makes his air allocation decisions. One of these decisions is allocation of close air support (CAS), which may be played as a "stream operation" with aircraft entering at predetermined times to support selected Blue battalions as necessary. (Strip alert is also an option.) Available attack helicopter support is similarly assigned to selected maneuver battalions. Supported units must be in contact with the enemy for CAS missions to be executed.
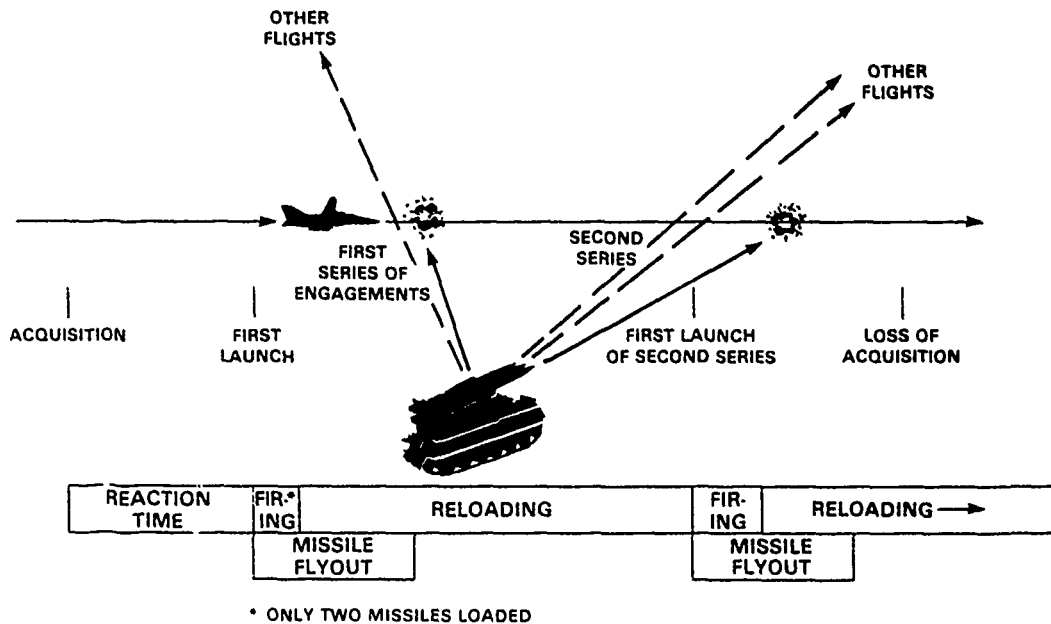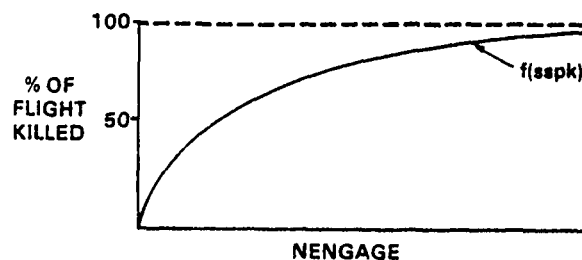
AIR DEFENSE EXAMPLE

* ONLY TWO MISSILES LOADED

Figure 2-20. Air Defense Example

AIRCRAFT ATTRITION

$$\text{NUMBER OF AIRCRAFT LOST} = NACFLT \times \left[1-E^{\left(\frac{-SSPK \times NENGAGE}{NACFLT} \right)} \right]$$

SSPK = SINGLE SHOT* PROBABILITY OF KILL (SYSTEM-ON-SYSTEM)

NENGAGE = NUMBER OF ENGAGEMENTS AGAINST FLIGHT

NACFLT = NUMBER OF AIRCRAFT IN FLIGHT

*(20 ROUND BURST FOR AAA)

Figure 2-21. Aircraft Attrition

42

2.5.3   PENETRATOR OPERATIONS

When the enemy element to be targeted is selected for a penetrator air attack, the command element estimates the enemy position at the time of the arrival of the strike aircraft. This becomes the "TARGET HEX" in terms of the computer model. The model, simulating the reacquisition function, has the ingressing aircraft begin a search for the target as portrayed in Figure 2-22. When a target is found, it is engaged, and the aircraft egress from that location. (The extended search pattern through egress, if no target is found, is depicted by the dotted line; this search pattern is also a model input.) Probabilities of visual acquisition and target classification are assumed for varying "RED OPERATION" and "FLIGHT PATH"-to-target geometries. The battlefield interdiction missions requested by the Blue division commander attempt only to attack the first armored vehicles they acquire (tanks, BMPs, self-propelled artillery, etc.), if they can classify the target. If not, they attack the first target they acquire; these are most often trucks due to the proliferation of these vehicles in the area.

The attributes of this logic and the benefit of classification capability (either by the strike pilots or by accurate vectoring to the location of sensor-classified targets) are each areas that influence the effectiveness of the air attacks.

2.5.4   AIR ATTRITION METHODOLOGY

Like artillery, aircraft can be armed and use a number of munitions from one of four types of munition categories: "Smart" bombs, "Dumb" bombs, "Nuclear" warheads and "Mines". Figure 2-23 illustrates the types currently defined in ICOR. Others can be defined by the users.

The attrition of a specific target weapon type due to an air attack is a function of the quantity of that specific target type of weapon in the attacked unit, the likelihood that the aircraft will actually attack the desired type of target, and the effectiveness of its attacks. The effectiveness is usually specified in terms of fractional damage for area weapons and kills per sortie for precision weapons. The actual attrition is a function of the munitions load of that particular type aircraft for

PENETRATOR SEARCH PATTERN
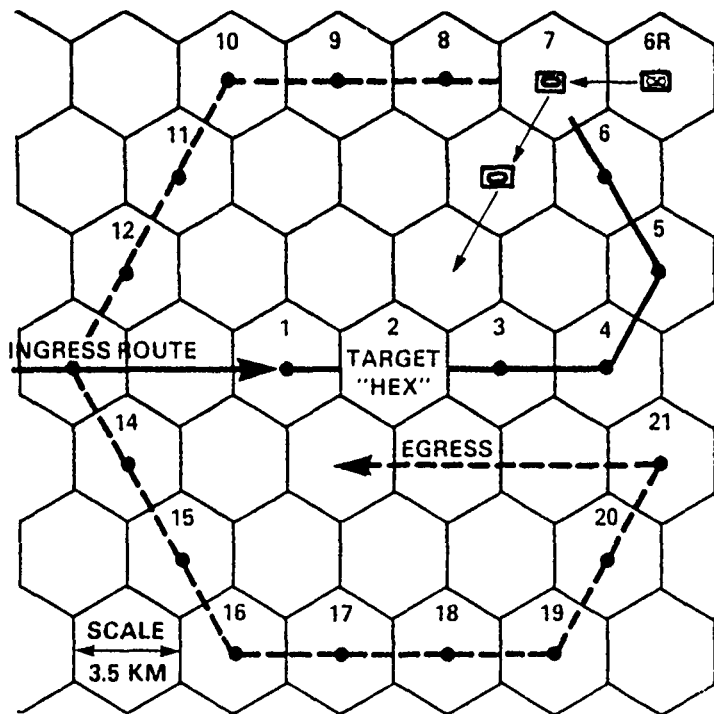
PROBABILITY OF ACQUISITION & CLASSIFICATION		RED OPERATION	
		ROAD MARCH	DISPERSED
ON FLIGHT-PATH (7)	(P_A)	.9	.8
	(P_C)	.9	.7
OFF FLIGHT-PATH (6R)	(P_A)	.7	.3
	(P_C)	6	.5

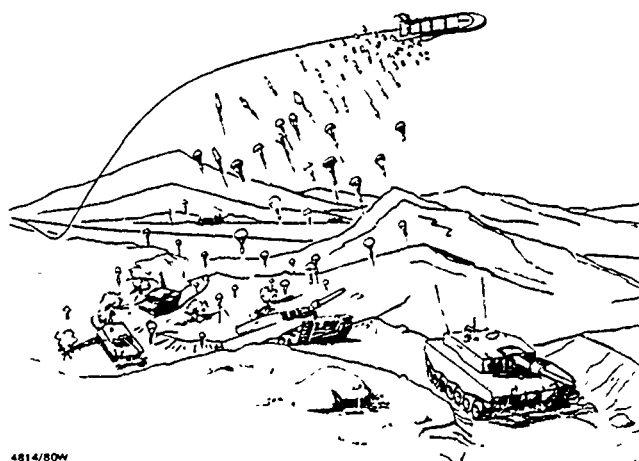Figure 2-22. Penetrator Search Pattern

AIR MUNITIONS

SMART PROJECTILES
- MAVERICK
- GAU-8
- HELLFIRE

DUMB PROJECTILES
- MK 20 ROCKEYE
- MK 82 HDGP BOMB
- ANTI-ARMOR CLUSTER MUNITION

NUCLEAR WEAPONS
- MK 57
- MK 61

MINES
- NONE CURRENTLY DEFINED

4814/80W

Figure 2-23. Air Munitions

that particular type of operation. The factor for the likelihood of attacking a particular weapon type permits the option to prioritize, for example, the attack of tanks or air defense weapons during an attack or to spread the losses proportionately over all the targets in the attacked unit. This applies only to "Smart" munitions. Figure 2-24 gives this formula. "Dumb" munitions use a formula similar to the artillery fractional damage equation.

2.6 INTELLIGENCE/SENSORS

ICOR has extensive explicit simulation of both sensors and the intelligence process. The physical processes of sensor operation are modeled in an automated fashion, while the tasking of the sensors (dependent on sensor type) is either partially automated or implemented by the man-in-the-loop commander. The five primary elements of sensor system operations considered are:

(1) Sensor system tasking,

(2) Sensor deployments (ground or aerial platform),

(3) Target detection,

(4) Target discrimination, and

(5) Sensor system reporting.

The actual sensors simulated include both current and developmental, imaging and signal intelligence systems. The tactical intelligence collection systems currently modeled in ICOR are shown in Figure 2-25.

Within the current model, the imaging information that can be obtained from a detection is a function of the sensor system and the target array used. The man-in-the-loop tasks each system individually, identifying mission time, duration of flight, flight path, radar or camera orientation, and "swath range" (when that is a system variable).

Imaging sensors vary in terms of the quality of information they can provide. The functional characteristics peculiar to various sensors are automated and geared to the actual occurrences on the battlefield. The vehicle "signature" is continuously modified by the actual operation being performed by the unit subject to sensing. In this fashion the masking associated with foliage or terrain contour can be implicitly treated to

AIR ATTRITION METHODOLOGY

$$A_{ij} = \frac{N_i \times W_{ij}}{\sum\limits_{ALL\ i} N_i \times W_{ij}} \times KPS_{ij}$$

WHERE:

A_{ij} = ATTRITION OF WEAPON i BY SURVIVING AIRCRAFT TYPE j

N_i = NUMBER OF A PARTICULAR TYPE OF TARGET IN UNIT i

W_{ij} = LIKELIHOOD OF ATTACK OF WEAPON BY j

KPS_{ij} = KILLS OF i PER SORTIE OF j

$\sum\limits_{ALL\ i} N_i \times W_{ij}$ = WEIGHTED SUM OF ALL TARGETS IN UNIT ATTACKED

Figure 2-24. Air Attrition Methodology

SENSOR SYSTEMS MODELED

IMAGING SYSTEMS		SIGINT SYSTEMS
AIR FORCE.	OPTICAL CAMERAS	TEREC II
	AAD-5	TR-1
	PAVE TACK	
	UPD-4	
	ASARS	
ARMY	MOHAWK SLAR	TEAMPACK
	I- SOTAS	AGTELIS
	ED SOTAS	TRAILBLAZER
		TACELIS
		QUICK FIX
		GUARDRAIL (IMPROVED. V)
		QUICK LOOK II

SENSOR MODELING

- EVENT DRIVEN AND TERRAIN DEPENDENT SIGNATURES

- FUNCTIONAL SENSOR MODELING

  SENSOR ATTRITION
  SENSOR RESOLUTION
  TARGET DETECTION
  TARGET CLASSIFICATION
  PROCESSING & REPORTING TIMES

Figure 2-25. Sensor System Modeling

account for the units' expected use of this cover and concealment during "operations" such as occupation of an assembly area as opposed to a road march. Currently, terrain masking effects are handled probablistically as a function of sensor stand-off, attitude, and the roughness and forestation associated with the terrain occupied by the sensed unit.

SIGINT system performance is similarly linked to the dynamics of the ground battle. The occurrence of a radio or radar emission is dictated by the associated units' communications-electronic doctrine and the stimuli the unit receives from the combat environment. For example, these stimuli can include the receipt of orders, the initiation of combat, calls for fire-, night- or weather-induced ground surveillance radar activity, air defense engagements of aircraft, etc. As a unit moves across the battle-field, its emitters move with it and their usage reflects the unit's situation both in numbers of emitters active and in rates of emission. This creates a dynamic electromagnetic "picture" of the battlefield, totally coordinated with simulated ground combat events.

SIGINT systems, both ground-based and airborne, are tasked by the man-in-the-loop for mission time, duration, and location. Scan rates and times to intercept, identify, and DF are all data inputs unique to each SIGINT system played. Netted operations with out stations are also explicitly represented. Currently, all intercepts and target locations are reports; there is currently no provision for prioritizing the search, processing, and reporting cycle within the designated frequency ranges.

2.6.1   PLANNING, MOVEMENT, MANEUVER MODELING BASED ON INTELLIGENCE
         REPORTS

Figure 2-26 illustrates some typical man-in-the-loop (MITL) decisions and the information on which they may be based, in terms of line of contact intelligence, as well as other sensor reports on deeper enemy activity. The "line-of-contact" intelligence describes the threat array perceived by each front line maneuver unit. The commander also bases his decisions on intelligence preparation of the battlefield (IPB), which includes such things as knowing the location of major access routes, knowing the location of areas to be avoided such as built-up areas and other

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PLANNING, MOVEMENT, MANEUVER MODELING
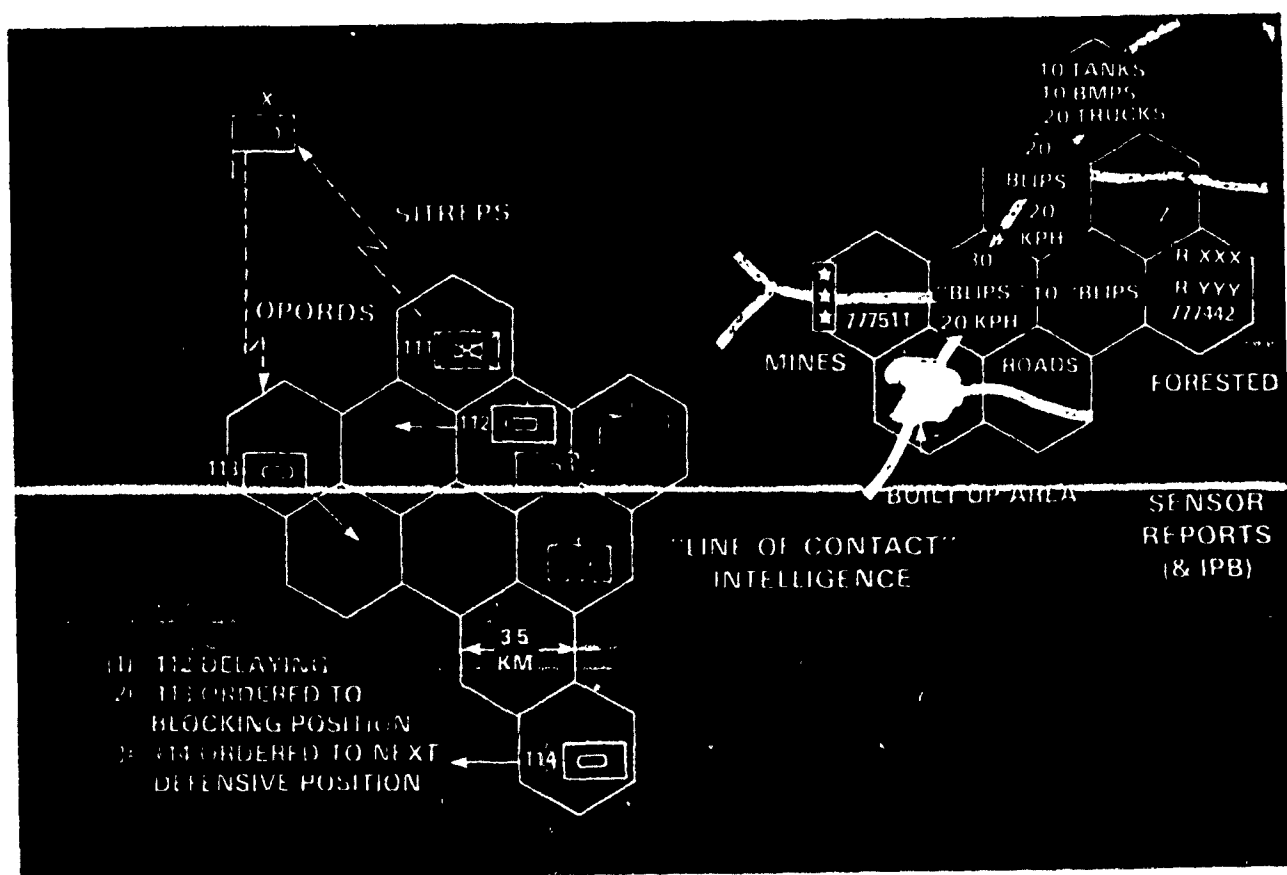
Figure 2-26. Planning, Movement, Maneuver Modeling

03856/80W

unfavorable terrain features, and generally knowing the Red concept of operation and order of battle.

When explicit sensors are included within the scope of analysis, various sensor reports are available as depicted in the set of hexes on the right side of the figure. The hex labeled "10 tanks, 10 BMPs, 20 trucks" shows the level of detail of target acquisition that is obtained from an imaging system such as an RF-4C aircraft, which gives an explicit count and classification of targets. The hex marked "20 'blips'" indicates the kind of information that is obtained from a SOTAS (a continuous surveillance moving target indicator radar), which gives a count and movement, speed, and direction (southwest, 20 kph) of the blips, but currently no classification. (Some classification capability is resident with the level of experience of the scope operator. In addition, an R&D program does exist to process doppler shifts of returning signals to discriminate tracked from wheeled vehicles.) The "10 'blips'" hex, which shows no movement or speed, is typical of the information received from a UPD-4 radar (a fixed target indicator radar) mounted in a RF-4C aircraft. If ELINT sensors are available, the intelligence presented to the MITL would include locations of radars, such as STRAIGHT FLUSH or GUN DISH, or if COMINT sensors are available, the location of multichannel ('R-XXX') and push-to-talk radios.

Given all of the available information, the MITL makes decisions and gives operations orders (OPORDs) to the units. Three examples of orders are listed at the bottom left. In addition to tasking of maneuver and fire support elements, there is a similar tasking for sensor elements.

2.6.2   SENSOR SYSTEM TASKING/SENSOR DEPLOYMENTS

Sensor system tasking can be performed in one of two ways. It can be preplanned from the start of a war or it can be performed during a model run by a man-in-the-loop acting as the appropriate commander. Whether preplanned or not, a sensor mission is specified by sensor type, desired arrival time on-station, mission cut-off time (if any), flight profile (for airborne sensor platforms), and other parameters specific to the particular sensor (i.e., orientation of the swept sector for SOTAS, UPD-4 swath selections, etc.). A sensor mission is assigned based upon availability of the requested system and mission priority.

Day/night and weather constraints on the systems are accounted for by not tasking photo systems to fly at night or IR systems to fly during poor weather etc. Additional environmental impacts can be input through probability of detection data.

For airborne systems the model utilizes flyout and flyback times, moves the sensor platform along the mission flight path (based upon platform speed), and upon mission end, calculates platform downtime for maintenance. Figure 2-27 illustrates the RF-4C photo/IR case.

The model also makes a draw on a survival probability to determine if, and when, a particular sensor platform is lost (based upon an average per sortie attrition rate). The attrition of a platform with no data link capability (e.g., an RF-4C photo flight) causes loss of all information gathered up to the point in time the sensor is lost, while a data linked system (e.g., SOTAS) transmits all data collected up to that point. The potential exists to have explicit ground-to-air air defense interactions with the sensors as is done for attack helicopters and TACAIR operations.

Ground-based systems are explicitly represented down to out station level of detail and are tasked similar to maneuver units. Road movement and set up/take down time are explicitly represented, as well as, vulnerability to air, artillery, and direct assault.

2.6.3   TARGET DETECTION/TARGET DISCRIMINATION

As sensors execute their missions, they have an opportunity to acquire targets to a certain degree of discrimination. One of three levels of target discrimination is possible, as defined in Figure 2-28. Probability of detection varies as a function of terrain, range, weather, and countermeasures conditions. The current methodology treats the finite target set as an entity, that is, the unit either is or is not detected. For example, if a noise jammer obscures the signal returned from one vehicle in a given area, it is likely to obscure the individual returns from the majority of vehicles in that same area.

The MTI (moving target indication) and FTI (fixed target indication) radar systems are required to check target radial velocities to

CRITICAL INCIDENT—2000 HOURS
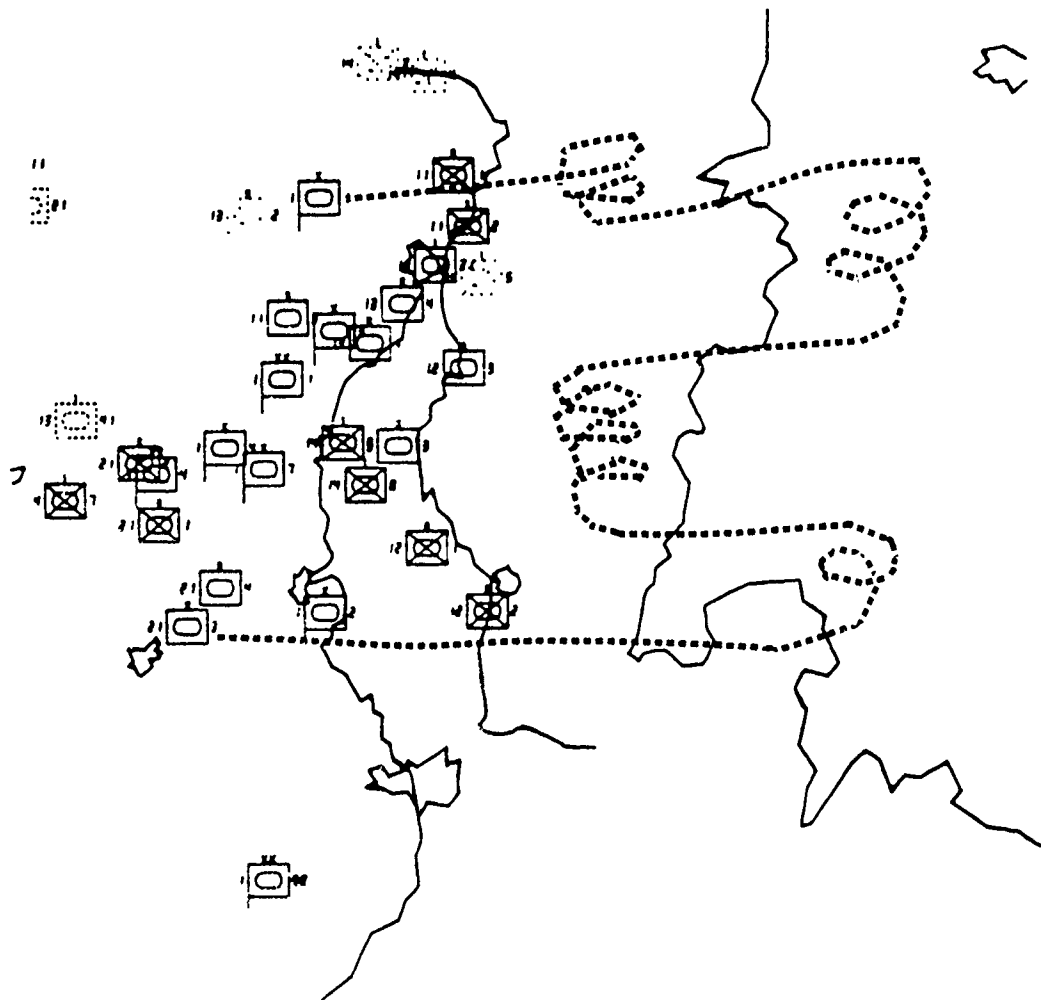# TADARS RPV INTELLIGENCE

Figure 2-27. Critical Incident - 2000 Hours
Tadars RPV Intelligence

LEVELS OF TARGET DISCRIMINATION

- "DETECTION"   — A POTENTIAL TARGET IS PRESENT

- "CLASSIFICATION"   — THE CLASS OF THE TARGET CAN BE DISCERNED (E.G., ARMOR VEHICLE, WHEELED CONVOY, ETC.)

- "IDENTIFICATION"   — THE TARGET CAN BE DE-SCRIBED TO THE LIMIT OF THE 'OBSERVER'S' KNOW-LEDGE (E.G., T-72 TANK, 22 KrAZ-255B TRUCKS, ETC.)

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Figure 2-28. Levels of Target Discrimination

assure they fall within individual system thresholds before registering a target detection. In addition, radar resolution is parametrically treated to account for the ability to accurately "count" the number of actual vehicles.

The fact that a target is detected by a sensor system does not indicate the information that the sensor system will derive from it. This is a function of sensor system resolution, information processing, and operator/analyst interpretation. The ability of the modeled system to discriminate a tracked vehicle from a wheeled vehicle, or further classify the target, is represented parametrically, to include first order (non-fused) operator/analyst capabilities (for example, the ability of the SOTAS scope operator to perform such classifications).

SIGINT systems, in turn, report out the total of their intercepts and target locations for the played interval of time. Target location error is reflected as a function of the system specification and is driven by the duration of the intercepted signal. Results to date, assuming automated search and DF capabilities, have generated more radio fixes than could possibly be exploited by manual means.

2.6.4   SENSOR SYSTEM REPORTING

After the sensor platform is tasked, the mission is executed, and targets are detected, the information is formatted and reported to the man-in-the-loop. The time at which the report will arrive at the user is calculated based upon distributions of system response time as derived from exercises (e.g., REFORGER), system planners, and military judgement. This provides a first-order approximation of the command, control, and communications delays associated with getting information from a given sensor system to the end user (e.g., division commander). Detailed imaging and signal intelligence reports provide the user with the same information he should expect to receive on the actual battlefield.

To aid in the presentation of the imagery intelligence, the data is translated to a computer graphics display. An example of this imagery is shown in Figure 2-29. The large dots (many being the origin of a

CRITICAL INCIDENT— 2000 HOURS
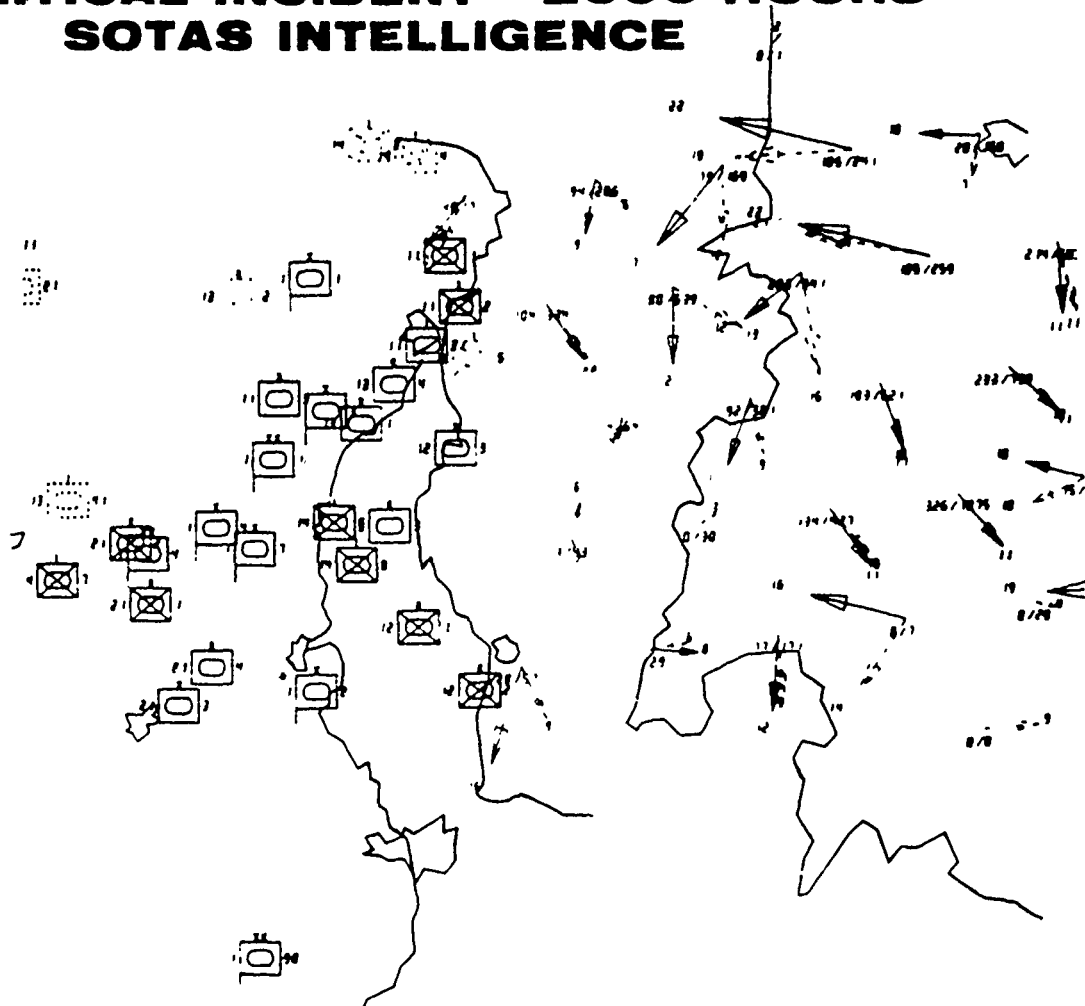## SOTAS INTELLIGENCE

Figure 2-29. Critical Incident - 2000 Hours
Sotas Intelligence

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vector) on the graphic represent the centers of hexagons 10 kilometers in "diameter."

The presence of a dot indicates a sensor sighting within 5 kilometers of that dot. A solid vector indicates information available on the general direction of armored vehicle movement (from sensor reports where targets are classified); a dashed vector is used for all vehicle movement if it differs appreciably from the armored vehicle movement alone. The number at the tip of each arrowhead represents the average speed of these vehicles (if known) in kilometers per hour. The two numbers below each dot represent, respectively as separated by a "slash (/)", armored vehicles classified in the hexagonal area and the total number of vehicles not classified as armored (primarily unclassified) in that same area. These graphics may be produced for both the Blue commander's perception of the situation based on sensor data and the actual Red mass and velocity data (i.e., ground truth available to the game controller).

During the course of an earlier study, the armored vehicle data became the critical intelligence on which the Blue commander made his decisions. The large number of Red support vehicles (i.e., trucks, which composed approximately half of the total vehicular array) literally added so much "clutter" to the sensor acquisitions that it was difficult to ascertain the intent of the armored and motorized rifle (mechanized) combat units, especially over five kilometers beyond the line-of-contact.

It should be recognized that this computer simulation presents a particularly dense, although not unrealistic, target environment. A typical scenario presents over 10,000 vehicles moving opposite the Blue division to a distance of up to 150 kilometers beyond the line-of-contact. Approximately 1,400 of these vehicles are tanks, and 700 are BMPs. The remainder consists of BRDMs, BTRs, SAM vehicles, and AAA vehicles, but the greatest number are trucks. Even large scale exercises, such as REFORGER, cannot come close to replicating either the density, or the unrestricted movement of an actual combat environment.

Figures 2-30 and 2-31 show some of the other types of aggregated intelligence output available to the MITL commander; these are examples of the emitter displays that can be produced by ICOR. The first figure is a consolidated display with different symbols used to indicate the various types of radar and multichannel emitters that have been detected over an interval of time. The second figure shows a notional distribution of push-to-talk radio emissions DF'ed over the battle area. Each enemy emission is displayed as an "o"; friendly emissions are not shown in this Figure but would be denoted by "x" symbols if desired. The purpose of this figure is to provide an indication of the intensity of radio activity over the battlefield; these sightings should be reasonably consistent with, and corroborate, the aggregated IMINT data.

2.7 COMBAT SERVICE SUPPORT

The explicit representation of combat service support is currently limited to the supply of conventional and nuclear ammunition. Figures 2-32 and 2-33 highlight the conventional and nuclear supply features. On the conventional side within ICOR, tonnages of ammunition are consumed by the maneuver and artillery battalions, reordered and shipped automatically within the supply network defined in ICOR. Various levels of supply depots are modeled and explicit convoys are used to move supplies above the regimental level.

The consumption of conventional ammuniton by maneuver units in combat is at a rate which is a function of the particular type of firing weapon, (i.e., M60 Tank TOW) the number of those weapons that are firing, and the type of target. Artillery units, on the other hand, consume at a rate which is a function of the number and type of rounds fired. In all units, supplies can be destroyed on board vehicles when the carrier is destroyed.

As a maneuver battalion's stock of supplies decreases, its rate of fire and its reaction to the situation can be affected automatically. Its unit effectiveness is tied to its supply levels. Reorder of supplies occurs as the reorder threshold is passed. These automated unit actions

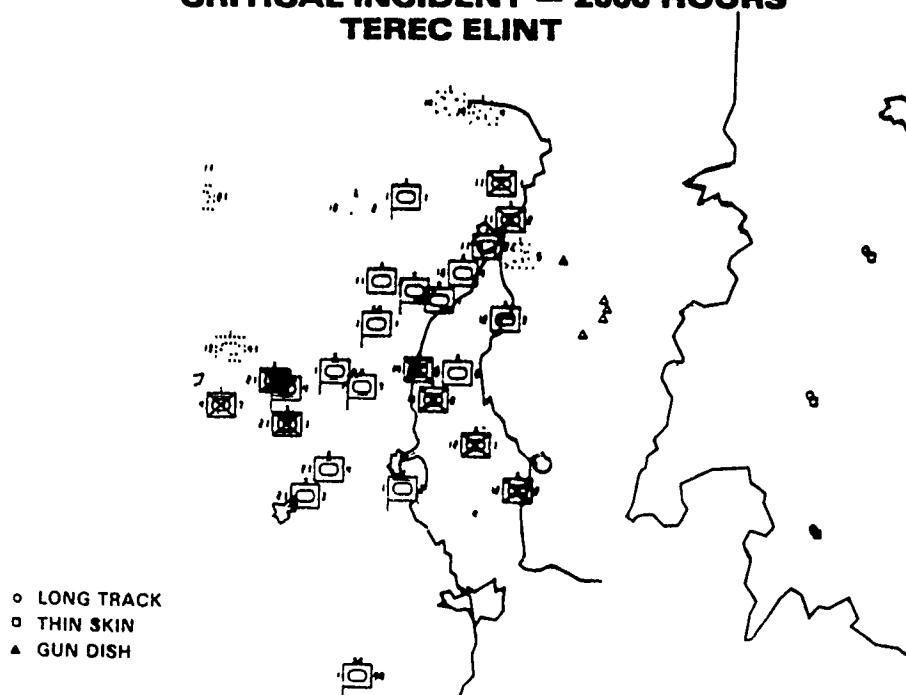**CRITICAL INCIDENT — 2000 HOURS**
TEREC ELINT

o LONG TRACK
□ THIN SKIN
▲ GUN DISH

Figure 2-30. Critical Incident - 2000 Hours
Terec Elint

CRITICAL INCIDENT — 2000 HOURS
GUARDRAIL COMINT (VHF PUSH-TO-TALK)
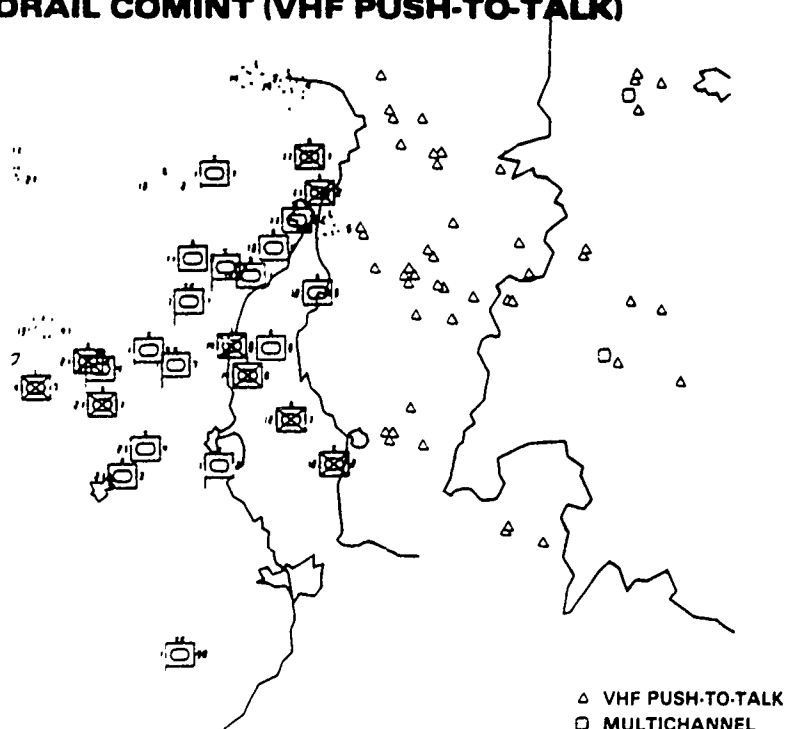

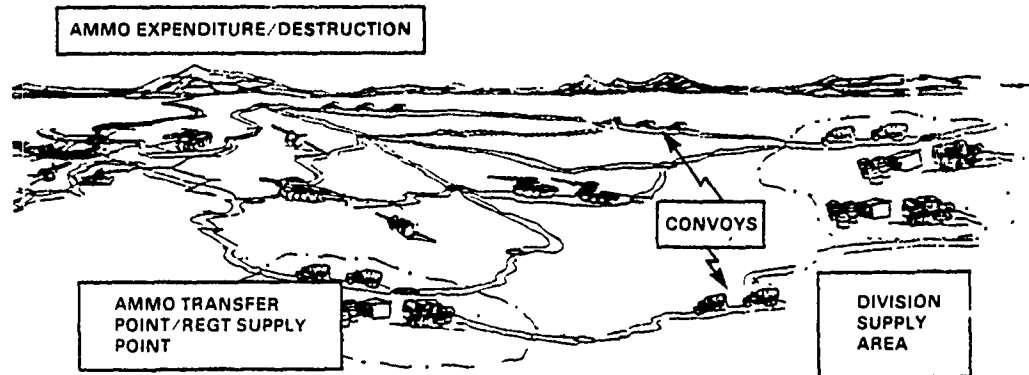△ VHF PUSH-TO-TALK
□ MULTICHANNEL

Figure 2-31. Critical Incident - 2000 Hours
Guardrail Comint (VHF Push-To-Talk)

COMBAT SERVICE SUPPORT
(CONVENTIONAL)

- EXPLICIT LOGISTICAL ELEMENT (DIV/BDE/REGT)
- AMMO TRANSFER: DIV-TO-BDE/REGT (CONVOY)
  BDE/REGT-TO-BN (IMPLICIT)

AMMO EXPENDITURE/DESTRUCTION

CONVOYS

AMMO TRANSFER
POINT/REGT SUPPLY
POINT

DIVISION
SUPPLY
AREA

4814 80W

Figure 2-32. Combat Service Support (Conventional)

COMBAT SERVICE SUPPORT
(NUCLEAR)

- EXPLICIT NUCLEAR SUPPLY ELEMENTS (CORPS/DIV/BN/ BTRY)
- WARHEAD TRANSFER: MAN-IN-THE-LOOP
- EXPLICIT ROUND ACCOUNTABILITY (YIELD, TYPE)

WARHEAD
EXPENDITURE/
DESTRUCTION

NUCLEAR WAR-
HEAD(S) WITH
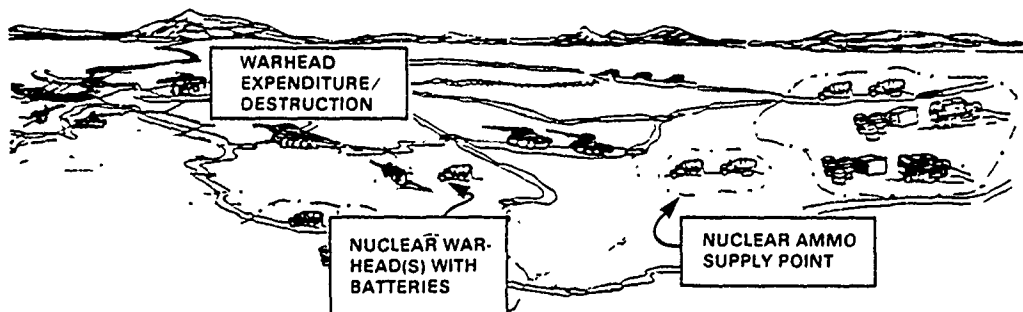BATTERIES

NUCLEAR AMMO
SUPPLY POINT

Figure 2-33. Combat Service Support (Nuclear)

POL?

are implemented through the ORS. Supply request are sent to the next higher supply element. Battalions request supplies from the ammunition transfer point at the brigade. The ATP gets resupply from the division. In resupplying the ATP's, the division forms and dispatches convoys of supply trucks to fill these orders. The convoys are explicitly represented within the model and can therefore be sensed, attacked, etc. At the regimental/brigade level, supplies are currently issued to battalions without explicit convoys. This is accomplished implicitly. ATP's for Blue or Regimental Supply points for Red issue supplies to those who demand them based on an allocation and a shipping rate associated with their capabilities and on the distance they are from the battalion wishing the supplies. Figure 2-34.

For the nuclear supplies, a more detailed treatment of the supply process is featured in the model. Individual warheads are tracked as opposed to the tonnage treatment given to conventional munitions. This shipment, however, does not occur automatically. The MITL needs to give specific orders to ship nuclear warheads in this system.

The reconstitution of materiel and units is currently implicitly represented. Figure 2-35 outlines the MITL methodology. After an appropriate interval of time, the man-in-the-loop controller can return to service a "repairable" increment of the "killed" vehicles. Transfer of materiel and re-forming of units is also a man-in-the-loop procedure. However, some of the reconstitution process is automated in that a ineffective unit recovers its capability (although not its materiel) if it is not in contact over a period of time. When the stocks at the highest supply base represented in the model run low, a message will be sent to the MITL requesting supplies from outside the model.
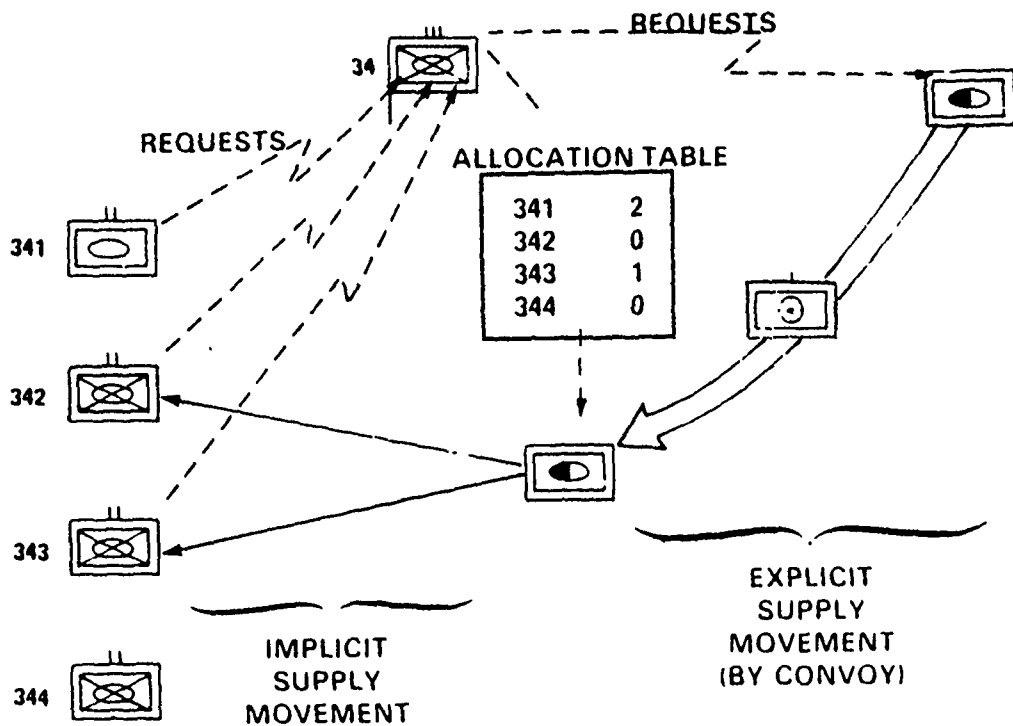
LOGISTICS MODELING
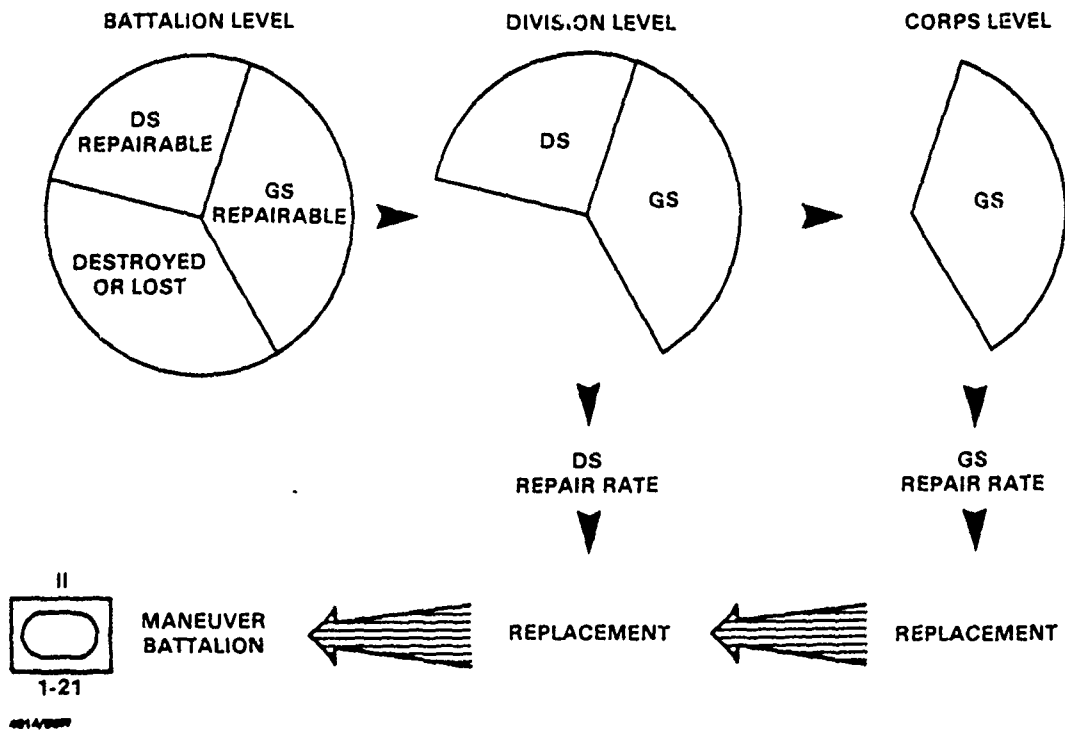

Figure 2-34. Logistics Modeling

MITL COMBAT REPAIR/ REPLACEMENT

Figure 2-35. MITL Combat Repair/Replacement